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Cooperative processing :

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COOPERATIVE PROCESSING:

THE COMPUTING CHALLENGE OF THE 90'S

by

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Abstract

In today's competitive environment, information is a critical asset for every organization. As organizations become more aware of the value of information, they also begin to understand their need for efficient access to it. The dynamic environment that exists today dictates the development of information systems with flexible architectures designed to accommodate widely dispersed and dissimliar hardware and software. The increasing number of hardware choices range from standalone PCs, networked PC/workstations, mid-range computers, to mainframes. Software offers many more choices as the number of programming languages continues to increase from Assembler, Fortran, COBOL, ADSO, C, to "fourth generation" languages. The diversity of computers and communications equipment has created a need for a cohesive connectivity strategy that allows communicating virtually anything, anywhere, anytime. Cooperative processing, a new approach in computer architecture, may be the cohesive solution to computer connectivity.

This thesis focuses on the understanding and implementation of cooperative processing. It will define cooperative processing and identify the issues that will challenge businesses/organizations in coping with this new technology. An adage, "I hear and I forget; I see

and I remember; I do and I understand", supports the importance of hands-on experience with a new technology. To help define this issue, this thesis proposes the use of cooperative processing for a distributed maintenance management application.

The ultimate goal of this thesis is to provide an understanding of cooperative processing and to provide a framework for managing its implementation. It will endeavor to bring relevant information and learning experiences about cooperative processing to future users. For it will be through the appropriate use of this technology that businesses be able to realize even greater benefits from their information systems.

I. Introduction

Information has become a primary resource to use in addressing business concerns. Much of the value of information for a business lies in the prudent use of information technology and in the adapting of it to fit the goals and culture of an organization. Some areas to assess when considering informational technologies include computer hardware, software, connectivity, and systems integration. The use of new technologies in these areas is the key to reaching not only new organizational goals, but also to establishing competitive advantages - something all businesses are striving to do. Information technology presents many challenges. For, sooner or later, every industry will be required to respond to information technology and its implications. In the next few years, organizations without proficiency with information technology, from their IS professionals to their executives, will be at a competitive disadvantage. As businesses seek new ways to gain a competitive edge, they will need to increasingly apply information technology in new fashions. One requirement, surely, will be the development of better information systems.

An emerging approach to the information system architecture is that of "Cooperative Processing" - a technology that entails the integration of multiple devices that share resources and process information efficiently and transparently. This will be the way of the future.

II. Cooperative Processing Defined

A. Definition

What exactly is cooperative processing? Cooperative processing is a strategy for the future of computing. In simplest terms it can be defined as the ability to share information across a broad base of small and large computers. By allowing the integration of multiple computers, we can share resources and process information efficiently and transparently, without sacrificing advantages inherent to particular functionality. Although this definition sounds fairly simple, it poses many issues requiring further clarification.

In more technical terms, cooperative processing will enable computers at all computing layers the ability to communicate peer-to-peer with one another. We no longer need to depend upon the master-slave architecture that currently exists where the mainframe is in complete control of all processing. No longer is the mainframe the only device that can initiate the process to start an application: now any computer can not only start, but also function without the availability of the mainframe controlling all processing. In the current master-slave architecture, the master (mainframe) is responsible for performing or supervising all tasks performed by the slave (personal computer). Only tasks performed by the mainframe can currently be performed real-time (all updating takes place at the time the transaction takes place). Currently, all transactions initiated by an individual PC/workstation must be captured and temporarily stored, to be applied at some later point in time. Peer-to-peer communications allows a PC/workstation the same status as the mainframe; the ability to execute functions in real-time, the ability to communicate with other devices, retrieve, store, and update data, as well as the ability to access peripheral and storage devices.

From a data access point of view, cooperative processing will allow data to be processed in an integrated fashion, reducing the access constraints imposed by data residing on separate machines. Multiple computing layers are sharing, "cooperating", with each other to retrieve data, with all of the processing transparent to the user. A request is submitted as if all of the data resided on the PC/workstation. All of the logic associated with processing and determining the location of the data in the network and transferring this data to the user is transparent. This allows a user at any location the ability to access data in the network exactly if the data were all stored at the user's own site. Currently, in order for a PC/workstation user to access data on the mainframe, he/she is required to suspend his/her PC/workstation application session and sign onto the mainframe. Then, the user must have a a good idea of where the desired data is located, what application contains it, and how to extract the data. This cumbersome process helps to explain the reluctance users exhibit toward embracing micro-to-mainframe links.

Cooperative processing represents a different approach to processing than we are accustomed to within the confines of the current available architectures. A general concept of cooperative processing helps to increase our understanding, but it is still difficult to provide a fully comprehensive and unambiguous definition since the technology is still in its infancy. Understanding the metamorphosis that cooperative processing is still going through, it may be more practical and helpful to rely on this working definition: Cooperative processing identifies an environment where two or more computers can jointly carry out a single business function.

B. The Impetus Behind Cooperative Processing

Cooperative processing was born of a need to optimize the utilization and performance of all computers to communicate with one another. Today's computing layers limit the benefits to be derived from information systems. Through an understanding of cooperative processing and how it will address the shortcomings of the current environment, a better appreciation of an architecture like cooperative processing can be gained.

1. Limitations of Current Computing Layers

Although it may seem as though computers have always been a part of the business environment, they have only existed for a few decades. Since its inception, the computer industry has been fast paced and continuously changing. What started out as one computer, one choice, has now burgeoned into many computers, many choices. The changes in the needs of computer users have dictated the introduction of new computing layers over the past few years. Most of these changes have presented solutions by offering the availability of new hardware. However, a change to the current environment is now being considered with a slightly different approach to modifying the current environment. Shortcomings from the current environment do not stem from the inadequacies of the hardware available, but rather from a need to connect the hardware. A new approach to computer architecture is needed. One new architecture to be proposed is cooperative processing. In order to fully understand and appreciate the capabilities of this proposed new environment, it is important to understand just how the needs of businesses have forged the computing layers of the past and present, and how cooperative processing will revolutionize the current computing environment.

The evolution of computing layers can be tied to the computer's ability to assist businesses in solving and overcoming their problems. When computers were first introduced, they simply provided an automated way to do manual jobs in a less time-consuming fashion. Computers were most applicable to tasks that required little analysis and a great deal of data manipulation (e.g. calculating, sorting, and filing) - providing significantly faster, more accurate and generally less expensive processing. Because of the high volume of data to be input, it made sense to automate such activities as payroll, order processing, inventory, maintenance, and billing (18). Given the nature of these early applications, a precedent was set for measuring computers in terms of reduction of costs. The benefits associated with the computer at this time dealt strictly with the cost savings in manual manhours versus automated data processing. Productivity gains resulting from the use of the computer as an administrative support tool was the only justification of the computer at this time. The idea of computers producing information for managers was not thought of at this time, but rather was an idea that evolved as the technology of computers matured.

Although powerful and full of potential, the mainframe had its limitations. While this architecture was ideal for organizations whose computer users were located centrally, mainframes were less effective in organizations where users were geographically dispersed.

The mid-range was the next layer of computers to be introduced. It was the first step toward smaller, more powerful machines, at a lower cost. Providing many of the same benefits as the mainframe, the mid-range found its own niche in the business world. Unlike the mainframe, the mid-range was not applied strictly to business data processing tasks, but also to scientific and production problems. For example, mid-range computers were used to monitor and control production machines, to automate inventory control, to test products, and to control heating, power, and water systems (18). Now, computers could be justified in the terms of added efficiency. The computer was recognized for its help in contributing to revenue, not just saving clerical costs. Initially, mid-range computers were distinguished from the mainframe in the following ways: limitations existed in terms of storage, processing speed, and internal operations. The mid-range computer offered many of the advantages associated with the mainframe, with few additional disadvantages. As the mid-range computers continued to become more sophisticated, the distinctive characteristics between the mainframe and mid-range computers seemed to become minimized.

For many years to come, businesses continued using mainframes and mid-range computers purely for data processing. However, as the computer usage in companies matured, there existed a need to use the computer for smaller, specialty applications. Then came the introduction of an even smaller computer than the mid-range - the microcomputer or personal computer. As the name implies, the "personal computer" (PC) was initially introduced as a computer that you own yourself. At first, the PC was just a novelty for the home computer user. But as its power and processing potential increased, the class of personal computer users has expanded and diversified, especially in the business world. Dataquest, A California marketing research firm, estimates that more than half of the personal computers bought are for business use, rather than home and hobby, educational or technical purposes (23). Throughout the evolution of computing, the trend has been toward lower-cost, smaller equipment with improved reliability and performance. The PC has this to offer plus many features that will lead to increased productivity - hence its popularity.

A more sophisticated microcomputer, that has evolved from the PC is the PC/workstation. Today's typical workstation is a stand-alone system with a 32-bit processor, main memory between 2 and 16 megabytes, and local mass storage up to 1,000 megabytes. It has 19-inch bit map display. It is capable of generating, storing, and retrieving complex graphics and is equipped with a sophisticated window manager that permits simultaneous displays of screens from two or more running programs. The workstation has become the most powerful, versatile personal computing tool available to engineers and designers. As stand-alone equipment, workstations offer exclusive access to a high-performance computer and private mass storage. They have a faster, more predictable response than timesharing systems. Moreover, workstations can be equipped with whatever system and application software each user might need - increasing its popularity. As it increases in popularity and gains market share, the realization that many businesses are coming to terms with is that the investment they have made in personal computing is an underutilized resource (23).

In today's environment the selection of a computing processing layer for an application is a complex one. It is made even more difficult because the current environment dictates that a business function be restricted to using only one of the computing processing layers. Because of the advantages and disadvantages inherent to each layer (Figures 1, 2, 3) applications have to endure some compromises, making it necessary to often identify approaches that minimize the disadvantages of a selected layer (17). With cooperative applications there is no longer a need to minimize disadvantages associated with the limitation of choosing one computing layer in which to develop applications in the future. Cooperative processing allows the integration of all three computing layers within an application, empowering each processor with the capability to perform the specialized functions that it performs the best. The framework for the 1990's style of applications development will be formed by the combining of these computing layers within an application.

It is important to remember that none of the computing layers in the current environment will be replaced or eliminated, but they will be integrated, the whole will be greater than the sum of the parts. The degree of success of the integration will depend upon the realization of the full potential of each computing layer and its ability to perform business functions in a cost-effective manner. Architectures will extend beyond today's standard configurations to include mainframe to mid-range, mid-range to personal computer, and mainframe to personal computer communications (Figure 4, 5).

SUMMARY OF MAINFRAME COMPUTER FEATURES
ADVANTAGES

- Supports a community of users
- Supports shared applications and data
- Supports standardization of systems for users
- Large computing power
- Large data storage
- Supports high degree of program integrity
- Supports high degree of data integrity
- Supports high degree of auditability
- Supports high degree of security
- Good cost allocation measurements
- IS technology experience is high
- Good backup procedures
- Hardware failure rate is very low
- Tool diversity with much technical functionality

Figure 1a

SUMMARY OF MAINFRAME COMPUTER FEATURES
DISADVANTAGES

- Variability of response times
- Development and change procedures are complex and time consuming
- Large impact as a result of machine failure/outage
- Hardware not easily relocated
- User technology experience is low
- Application software portability is low
- Purchased software availability is limited
- Complex charge recovery mechanisms
- Many development tools exist, not always easy to use

Figure 1b

SUMMARY OF MID-RANGE COMPUTER FEATURES
ADVANTAGES

- Less expensive than mainframe
- Supports a community of users
- Large computing power
- Large data storage
- Supports graphics
- Hardware failure rate is low, but not as infrequent as the mainframe

Figure 2a

SUMMARY OF MID-RANGE COMPUTER FEATURES
DISADVANTAGES

- Variability of response times
- Rudimentary development and change procedures
- Hardware not easily relocated
- IS technology experience is low
- User technology experience is low
- Application software portability is low
- Purchased software availability is limited
- Hardware selection usually limited to one vendor
- Limited availability of shared database management software
- Limited availability of security software
- Limited availability of charge recovery mechanisms

Figure 2b

SUMMARY OF PERSONAL COMPUTER FEATURES
ADVANTAGES

- Many purchased software applications available
- Consistent response times
- Supports graphics
- Hardware is easily portable
- Hardware portability allows networking and distributed computing
- Hardware is expandable in small, less expensive units
- Software is easily portable
- Supports high degree of end-user use because of user-friendly software
- Tool diversity and tools are easy to use
- Provides high productivity level for user

Figure 3a

SUMMARY OF PERSONAL COMPUTER FEATURES
DISADVANTAGES

- Supports only one user at a time
- Supports smaller volumes of data
- Operating system is not static
- Limited availability of shared database management software
- Limited availability of security software
- Limited availability of charge recovery mechanisms
- Hardware failure rate is high
- Hardware portability reduces security
- Subject to long repair times
- Ability to access data from other sources is limited
- Backup procedures are manual

Figure 3b

CURRENT COMPUTING ARCHITECTURE

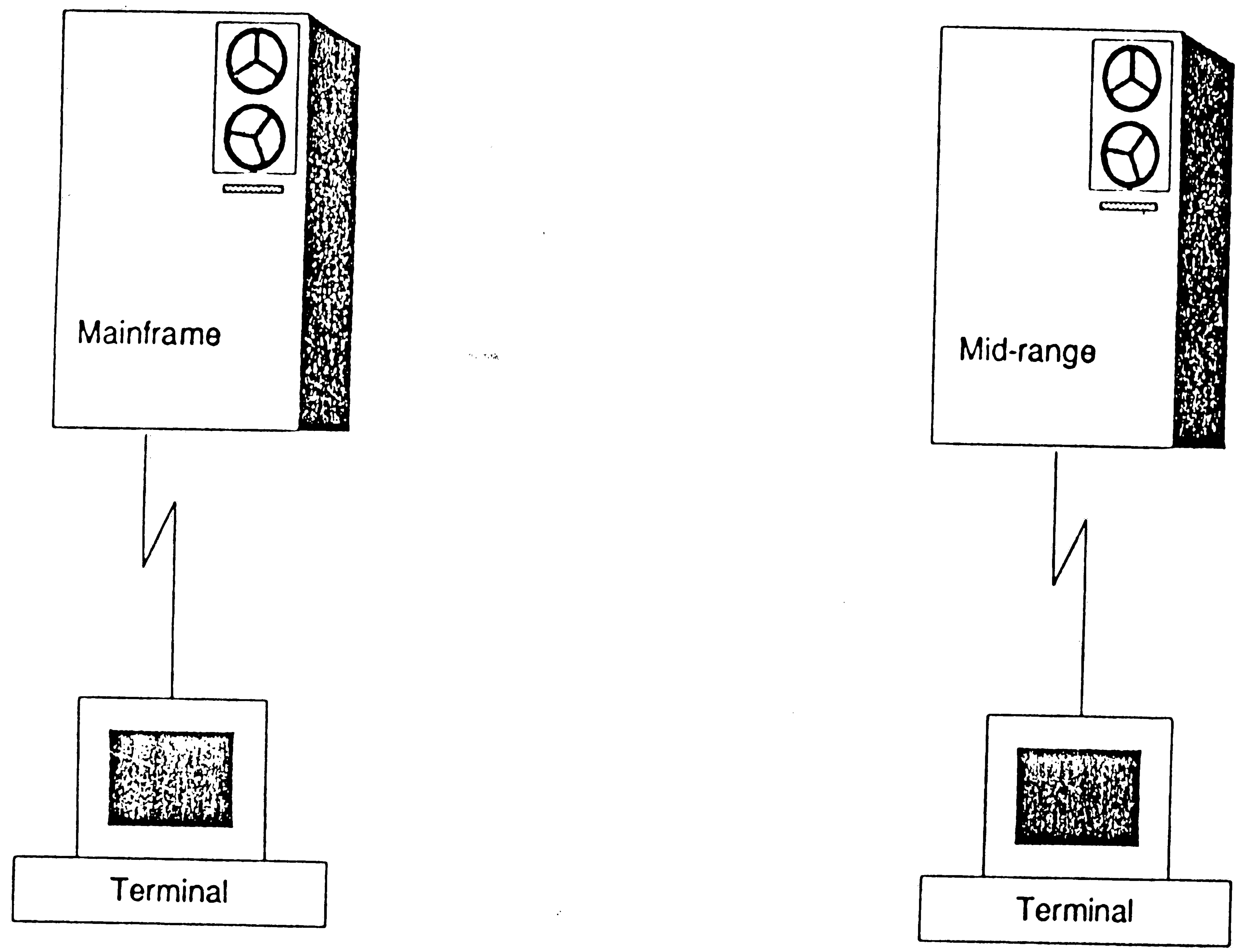


Figure 4

COOPERATIVE COMPUTING ARCHITECTURE

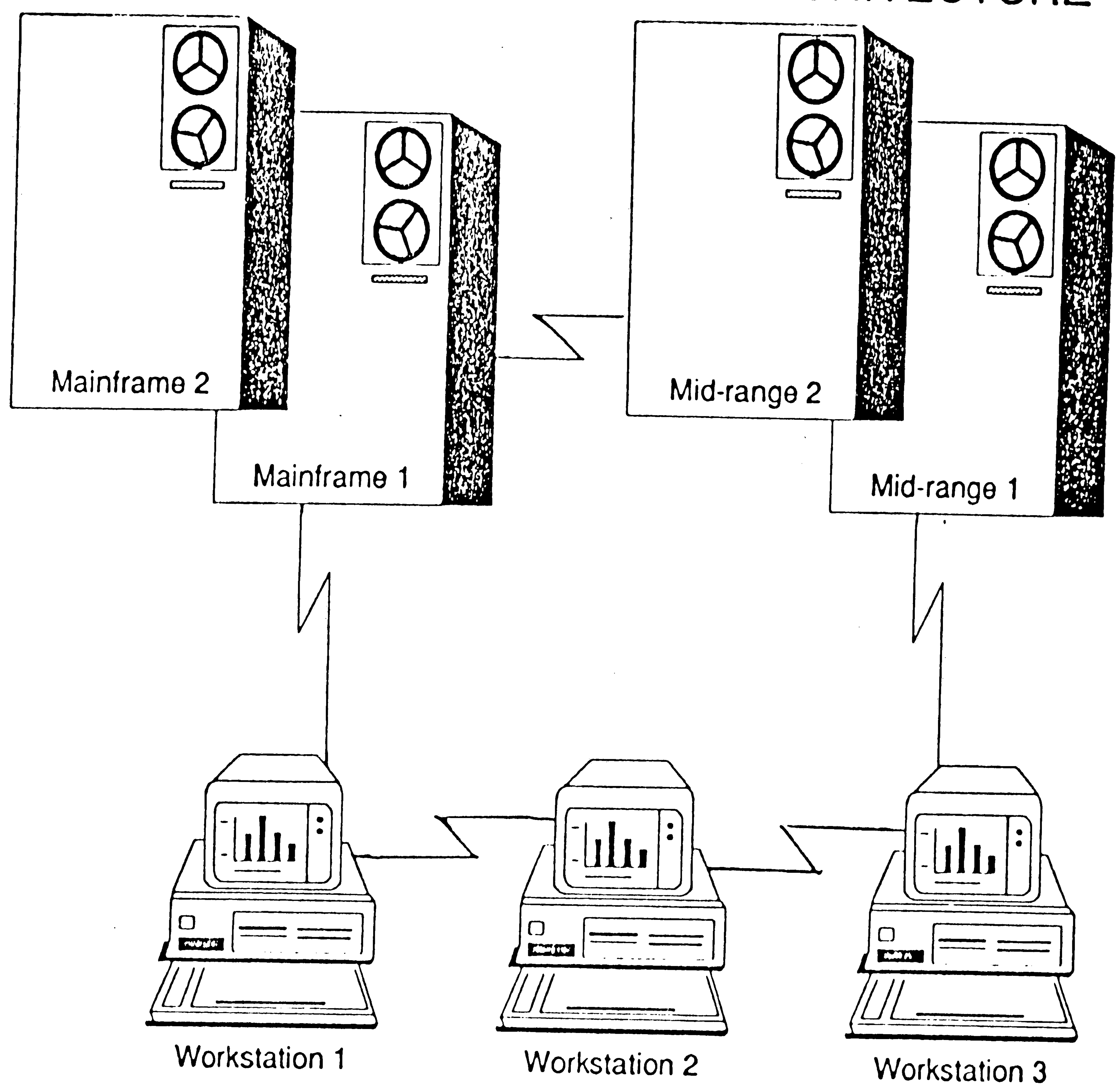


Figure 5

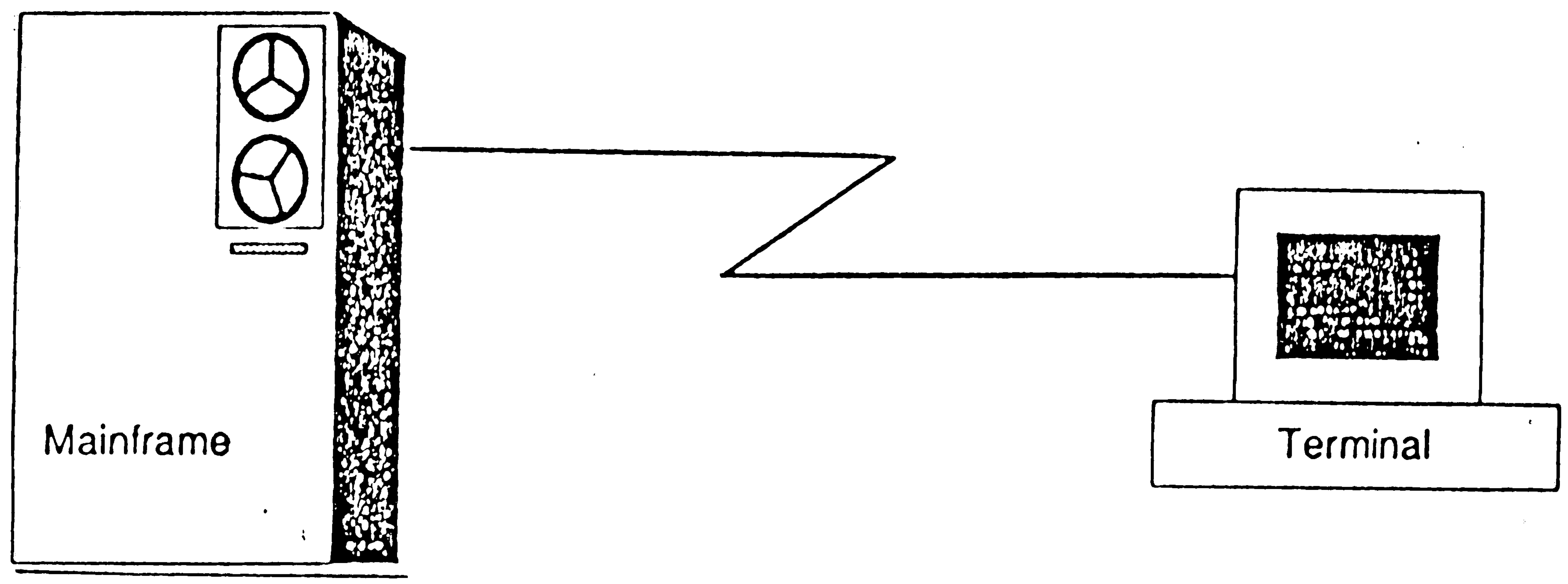
Cooperative processing offers significant advantages over conventional processing in the application component, and not only by increasing the amount of participation by the PC/workstation. It allows a different assignment of tasks associated with the three processing components of an application (human interfacing processing, application processing and database processing), and matches each of these components to the most appropriate processor (2). A scenario combining all computing layers to share the processing for the processing components of an application might be as follows:

- The increasingly powerful PC/workstations will be able to handle the graphics, color, and presentation which is geared toward the human interface.
- The mid-range computer, by providing large memories and high performance would handle the flow of control and the application processing and logic.
- The mainframe would house the large databases and handle all database input and output and other essential background tasks

This type of architecture provides for decentralized processing and centralized data storage, ensuring efficient processing as well as accurate data. Through the use of cooperative processing, architectures involving the use of computers from all three computing layers can be accomplished in many ways to meet an application's needs, ensuring each computer is used to its best capacity.

Cooperative processing not only defines a new architecture for computing layers but also a new assignment of processing tasks within these layers. Currently, mainframe-based applications use the mainframe exclusively to execute all of the tasks within an application. All development tasks, with the exception of screen presentation, are performed exclusively by the mainframe (Figure 6). By allowing the PC/workstation to be viewed as an intelligent processor, cooperative processing manages to transfer many of these tasks from the mainframe to the PC/workstation. This minimizes the amount of data to be moved from the mainframe to the peripheral device, thereby reducing communications loading. This transferring of tasks allows the developer to design a system that offers many advantages over a more traditional system. Even though the PC/workstation is taking on an increasingly important role, its role in cooperative processing will not be to replace the mainframe or mid-range computer, but rather to enhance the current environment.

RESPONSIBILITY OF PROCESSING TASKS
CURRENT ENVIRONMENT

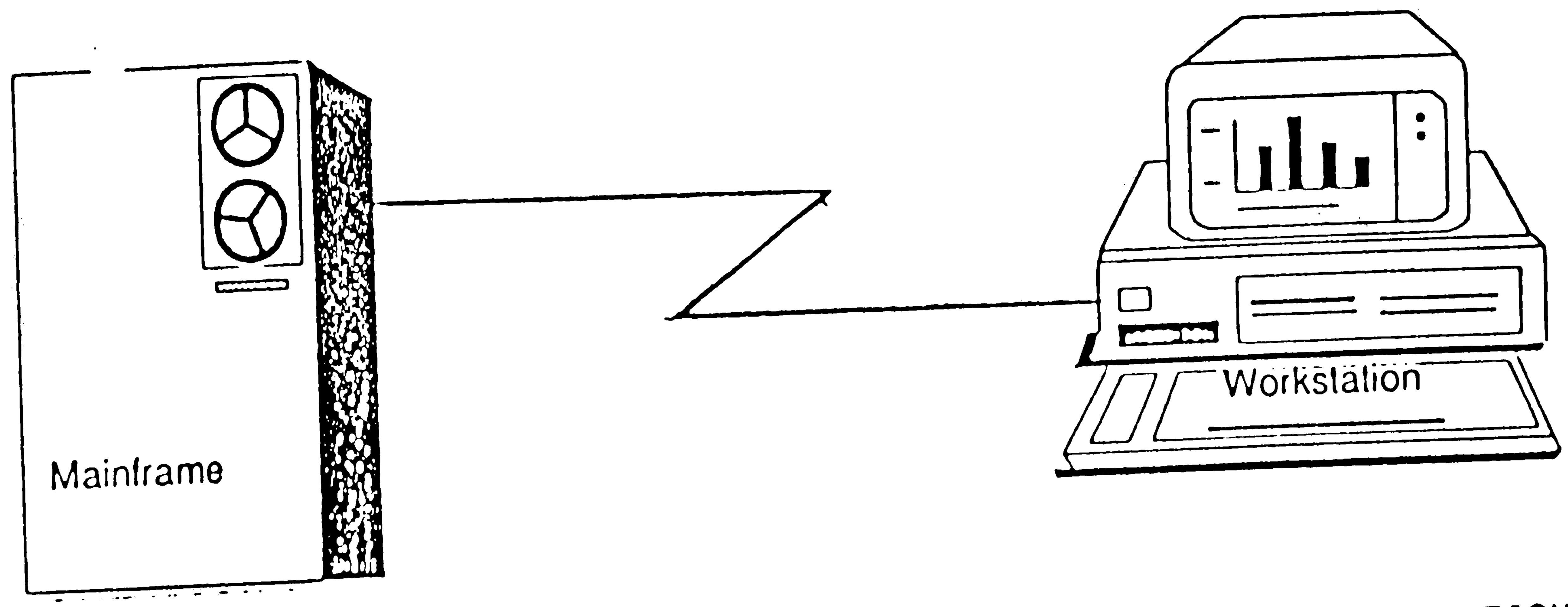


FILE I/O
APPLICATION CONTROL
FIELD EDITING
CALCULATIONS
HELP SCREEN PROCESSING
ERROR PROCESSING
CONCURRENT DATABASE ACCESS

SCREEN PRESENTATION

Figure 6a

RESPONSIBILITY OF PROCESSING TASKS
COOPERATIVE PROCESSING ALTERNATIVE 1

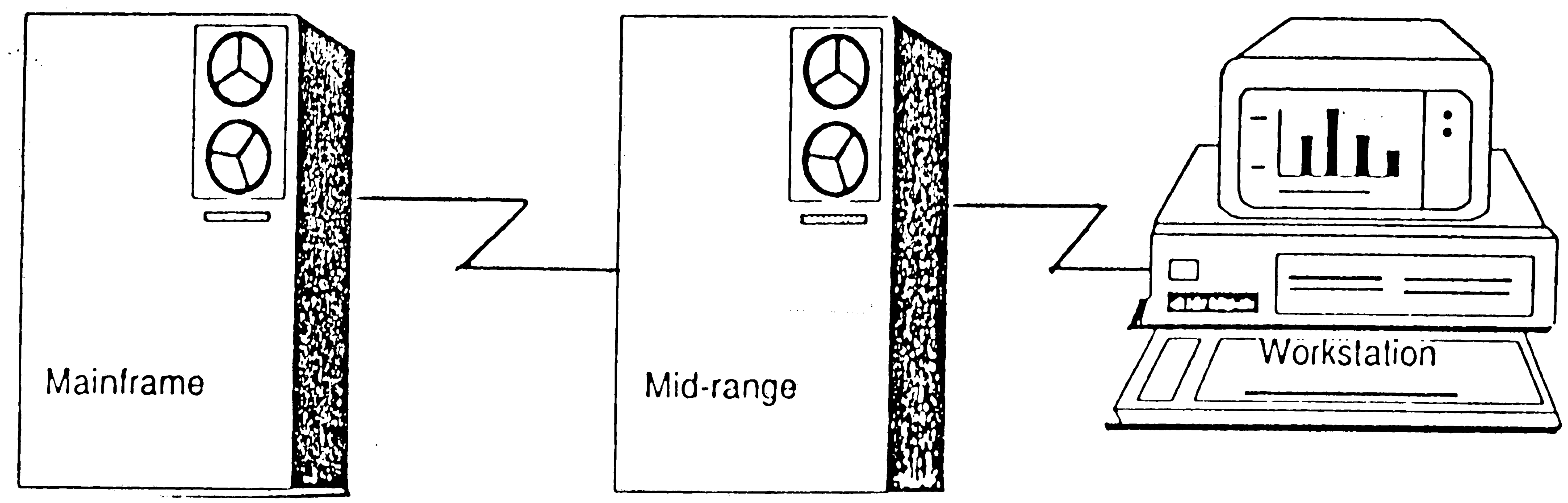


FILE I/O
CONCURRENT DATABASE ACCESS

SCREEN PRESENTATION
APPLICATION CONTROL
FIELD EDITING
CALCULATIONS
HELP SCREEN PROCESSING
ERROR PROCESSING

Figure 6b

RESPONSIBILITY OF PROCESSING TASKS
COOPERATIVE PROCESSING ALTERNATIVE 2



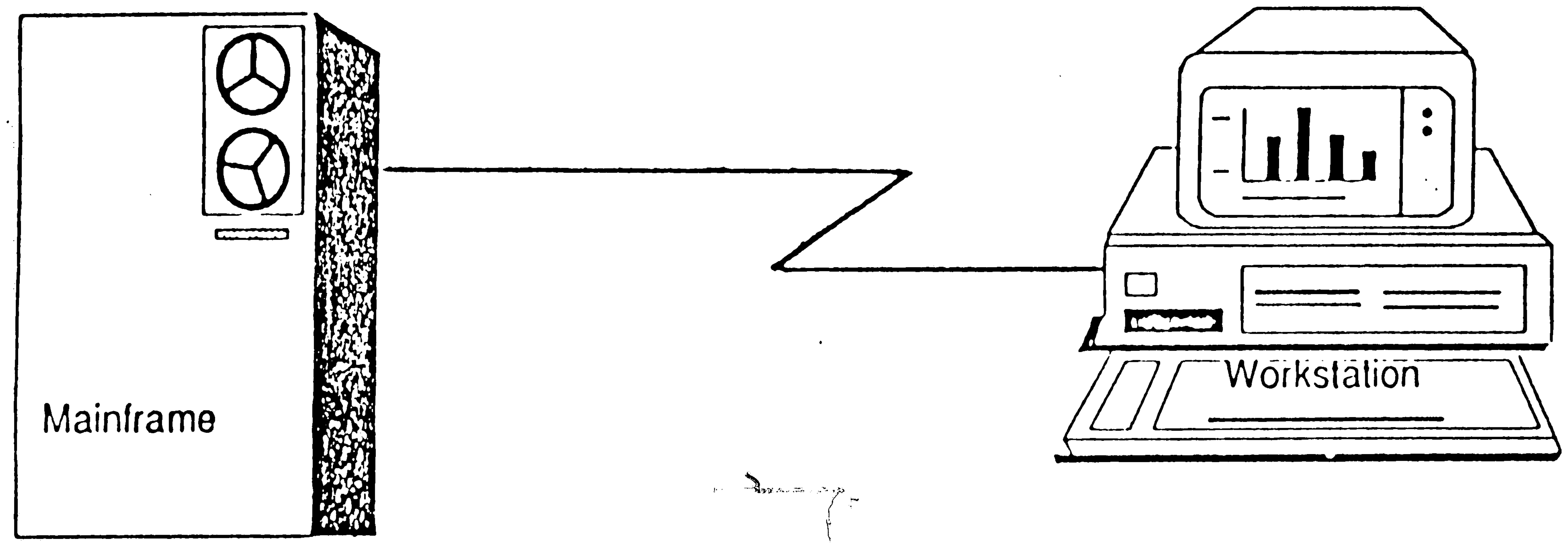
FILE I/O

APPLICATION CONTROL

SCREEN PRESENTATION
CONCURRENT DATABASE ACCESS
FIELD EDITING
CALCULATIONS
HELP SCREEN PROCESSING
ERROR PROCESSING

Figure 6c

RESPONSIBILITY OF PROCESSING TASKS
COOPERATIVE PROCESSING ALTERNATIVE 3



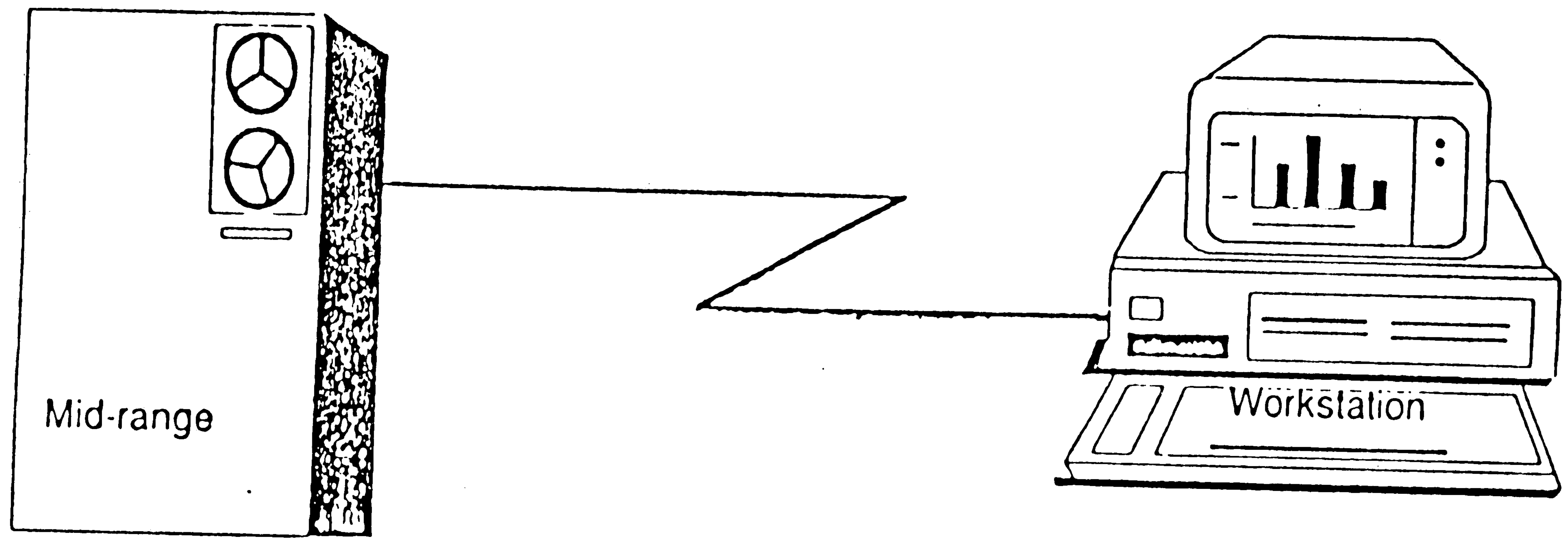
FILE I/O
APPLICATION CONTROL

SCREEN PRESENTATION
CONCURRENT DATABASE ACCESS
FIELD EDITING

CALCULATIONS
HELP SCREEN PROCESSING
ERROR PROCESSING

Figure 6d

RESPONSIBILITY OF PROCESSING TASKS
COOPERATIVE PROCESSING ALTERNATIVE 4

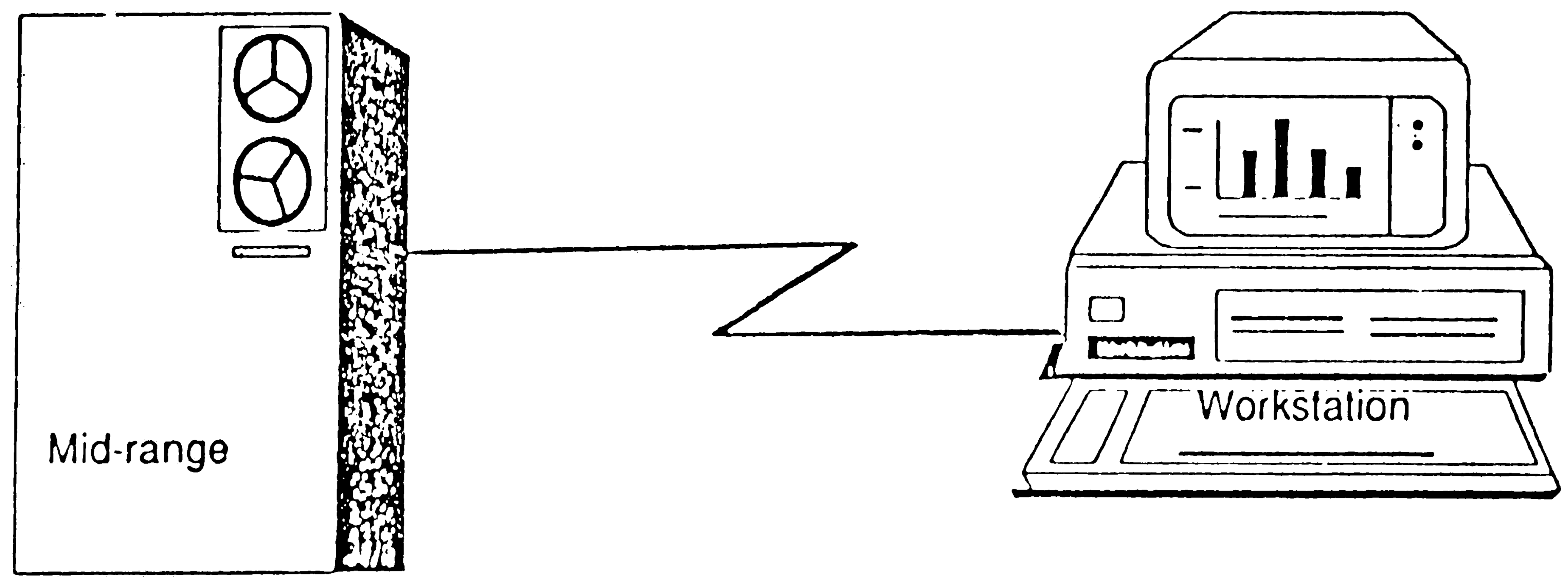


FILE I/O

SCREEN PRESENTATION
CONCURRENT DATABASE ACCESS
FIELD EDITING
CALCULATIONS
HELP SCREEN PROCESSING
ERROR PROCESSING
APPLICATION CONTROL

Figure 6e

RESPONSIBILITY OF PROCESSING TASKS
COOPERATIVE PROCESSING ALTERNATIVE 4



FILE I/O
APPLICATION CONTROL

SCREEN PRESENTATION
CONCURRENT DATABASE ACCESS

FIELD EDITING
CALCULATIONS
HELP SCREEN PROCESSING
ERROR PROCESSING

Figure 6f

2. Limitations of Current Architectures

The shortcomings that cooperative processing seeks to overcome have been addressed by other architectures, but have not met with complete success to date. The architectures that are available (PC LANs, distributed processing, and distributed databases) offer some of the capabilities of cooperative processing yet fall short of the complete solution offered by an architecture that includes cooperative processing. In order to increase our understanding of cooperative processing, it will be useful to understand why the other architectures fall short of the processing power of cooperative processing.

One architecture available today is the PC LAN. PC LANs offer the capability for one PC/workstation to effectively communicate with other PC/workstations. However, PC lans are limited to homogeneous devices. Connectivity between homogeneous devices can be rather limiting and offers no solution for the lack of connectivity between the mainframe and a PC/workstation. Besides the connectivity issue, there is also the issue of efficient data access. In the PC LAN architecture, one PC serves as a file server and all queries are done on the PC/workstation. When data is requested, one record at a time is sent to the PC/workstation via the PC LAN, then the processing is executed at the requesting PC/workstation to determine whether the record sent meets the selection criteria. If it does, the record is kept and processing continues. If the selection criteria is not met, another access to the file server is needed to send the next record to requesting PC/workstation to be evaluated for processing.

Another available architecture is distributed processing. Although it may seem as though distributed processing would handle application needs in the same manner as cooperative processing, it does not. While both distributed and cooperative processing involve the dispersing of processing among several computers, cooperative processing does offer one particular advantage. While distributed processing relies on batch transmission of data between nodes in a network, cooperative processing requires real-time access to a centralized database (5). In distributed processing all of the application processing is done at the remote site computer with the data being furnished via a batch download from the mainframe to the PC/workstation. Data that is needed by each remote site must be downloaded periodically (e.g. each night). The following day, a batch upload is run from the remote site to update the central database. At run time, distributed processing offers some advantages over centralized processing such as reduced communication costs, predictable response time, and high availability of a dedicated process. However, it is not without its disadvantages. The data required to complete a transaction may not always be available on the local processor, causing delays in the processing of transactions. Also, without real-time access to current data, users do not get timely information. Requests for information are not based on timely data, but rather the information from the last update, which is usually one day old. Distributed processing has several other technological problems associated with it that cooperative processing offers solutions to overcome. These problems include: redundant data, excessive software, poor response time, low system throughput, communication delays, excessive communication overhead, and high communication costs.

In response to the inherent weaknesses of distributed processing, distributed database technology has emerged as another architecture option. A distributed database is more than just a network of related databases. The key to qualifying as a true distributed database is the ability of a database to present the image of a single database to the user. In other words, a request is submitted as if all of the data resides on the local processor. The distributed database system is then responsible for finding the data, wherever it is stored. All of the complex logic associated with determining the location of the data in the network and transferring the data to the requesting processor is transparent.

This architecture addresses the major weakness of distributed processing by eliminating the use of a segmented database and instead provides concurrent, real-time access to all of the data in a system.

However, it does not address all of the advantages of cooperative processing. First, in order to operate with a distributed database, all of the data that is required by an application must be downloaded into the distributed database. For a new application that will build its own unique database, this presents no problem. However, if a system must access data that currently resides in a centralized database, the data has to be loaded into the distributed database. One solution to this transfer problem would be to transfer all of the data required by the new application into the distributed database. The drawback with this is that the developer must rewrite all of the existing programs that access the data in the centralized database, magnifying the level of effort necessary to develop this type of approach. An alternative would be to duplicate the data that is currently stored on the mainframe. Unfortunately, this approach has all of the drawbacks that are associated with redundant data. It will be difficult to keep the data in the two databases synchronized. A third problem with distributed databases is related to security issues (20). Most corporations have integrated their databases into their security systems. A new database will require changes. In particular, geographically distributed data as well as geographically distributed access to that data, poses a problem in terms of data security. All of the current security systems in place protect data that is stored in a centralized processor. There are no systems that provide external security for distributed databases at this time, to our knowledge.

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Cooperative processing simultaneously addresses the drawbacks of PC LANs, distributed processing, and distributed databases. Where PC LANs provide for processing in a single homogeneous computing layer, cooperative processing allows for a heterogeneous multi-layer computing environment. Where distributed processing relies on the batch transmission of data between nodes, cooperative processing allows for real-time access to a central database. And while distributed databases force the user to convert data and applications to a new database, cooperative processing allows the developer to create applications that access existing databases.

3. The Emergence of the Personal Computer/Workstation

In the initial years of computer use, large corporations, government, and universities controlled the computer resources because they possessed the wealth and know-how. But the maturation of technology has reduced costs and simplified use enough so that every individual can benefit from computers. One of the most recent revolutionary changes in computer technology making this possible has been the introduction of the personal computer. Once dominated by mainframe and mid-range computers, the market place is seeing an increasing number of personal computers appear (Figure 7). This technology has added the most complexity and capability to the computing environment and will probably continue to do so. The power and cost effectiveness of the personal computer provides new opportunities for creative companies to solve business problems, exploit new business opportunities, and lower the cost of business operations. Although initially introduced for use in the home, the PC in its short-lived corporate life, has made a significant mark on businesses. As the business world becomes increasingly computer literate, the computer is becoming prevalent in many places outside of the home including corporate headquarters, regional offices, and small business offices. In large businesses today, approximately 15-20% of the white-collar workers have a PC/workstation at their desk (8). That is not to say that personal computers were ushered into businesses without justification. Businesses were challenged to provide justification, especially for professionals, for the usage of the PC. For secretaries and clerical workers, it was easy to justify them since there were tangible benefits and productivity measures were straight forward. Productivity measures did not seem to be as easily measured for managers and professionals. So rather than measure increased productivity, professionals are using the PC to measure increased efficiency - efficiency gained by the use of automation to augment the ways in which they work. By using PC/workstations to address problems of strategic significance, many companies are discovering the "value-added" benefits of the computer (24). This value-added focus is leading the industry away from replacing people with computers and toward applying tools to help people become more effective. As a result, businesses are shifting attention from using the PC/workstation as an administrative support tool, to using it more as a support tool for executives, managers, and professionals. Like the telephone, the computer is becoming indispensable to many professionals. Architects are using it for designing, accountants are using it for financial planning, and sales groups are using it to create sophisticated presentations. With all of this available at their fingertips, professionals have come to realize the potential of the PC/workstation as one of the most productive tools invented for them.

The introduction of the PC/workstation to the user, as well as to IS organizations, has changed people's orientation toward computer productivity. But there is still much productivity potential that exists on PC/workstations that can not be delivered today because of other limitations. One of the major limitations is the current operating systems available in the PC environment. Personal computers have the capability to do more than their current single task operating systems allow them to do. The evolution of a sophisticated operating system on the PC/workstation will be a major factor in the increased power, productivity, and popularity of the PC/workstation. As the PC/workstation becomes a more powerful tool, the users will demand the inclusion of PC/workstations as an integral part of their computing environment. With the introduction of OS/2, IBM's newest PC operating system, the trend toward a shared environment is even more imminent.

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OS/2 is designed to provide an interface flexible enough so it could be applied across a variety of hardware systems and software application while providing enough consistency to avoid retraining (13). It offers more of the standardization found on the mainframe from the development point of view, so programmers can concentrate more on better applications instead of writing interfaces. In this way, OS/2 will be instrumental as it integrates much more closely to the operating system, allowing most applications to be written to interface with the operating system, and not the hardware. Hardware diversity can now increase as long as the vendor creates an OS/2 driver. With the availability of OS/2, PC/workstations will also be able to take advantage of multi-tasking. The ability to automatically kick off background communications to retrieve and save information as part of a spreadsheet of database application is one of the major benefits of OS/2. OS/2 will be the platform for significant advances in software functionality and distributed processing.

OS/2 removes the 640 core (K) memory limitation and provides for 16 megabytes (MB) of physical memory and up to 1 gigabyte (GB) of virtual memory. Larger disk capacity is another aspect of the PC's popularity. While once considered a drawback for the PC/workstation, storage capacity is no longer a major concern, and in fact, has increased its popularity. The PC's storage capacity has increased, while costs have dropped significantly.

In addition to increased disk capacity, the maturation of PC software will allow for systems with much enhanced functionality. During the course of its development, significant changes have been made to PC software, to make it both user-friendly and more powerful. These changes have been noticed especially in the area of PC database managers. Unlike earlier products which were simple file servers, current PC database software offers sophisticated database management tools, allowing users to take on more advanced tasks by themselves (8). That is not to say that users have succumbed to the limitations of earlier software. Quite the contrary, in fact they have shown creativity in forcing some of the software to perform to its limitations. For example, Lotus 1-2-3, originally introduced as a spreadsheet, is being pushed to its limits and is being used as a database manager by some users. With the available hardware, software, and disk capacity, organizations now have more choices in the designing of database applications. Currently, most organizations maintain their production database systems on the mainframe, for no other reason than that is where the technology originated and it seems to work, so they resist change. But now there are savings to be realized by using the PC/workstation. It may be possible to locate some of the smaller databases within an organization to the personal computing layer without having to worry about size and software limitations. Figure 8 provides a sample listing of the production databases that currently exist at a Fortune 200, large manufacturing company. A simple analysis of the size and cost to store a database on the mainframe provided by Figure 8 will reveal that there are some obvious cost savings associated with storing smaller databases on a PC/workstation, rather than the mainframe. Currently, all of these databases are housed on the mainframe, primarily for two reasons. First, at the time they were developed, PCs did not have the disk capacity to store the database files. Second, most of the IS professionals have limited exposure to PCs and are mainframe oriented. Therefore, they have chosen a technology simply because they are familiar and comfortable with it.

Personal computing, the personal computer's greatest virtue so far, is becoming its greatest limitation to some extent in the business world. Too often, the PC/workstation is used in stand-alone mode. Many of the applications developed on a PC/workstation never get beyond the single user mode. This can cause problems leading to duplication of effort, lack of standards, poor control, and worse yet, limited usage of developed applications that could potentially benefit others. As the number of knowledgeable stand-alone personal computer users increases, their demands to share information and expertise will also increase. People in business do not work well alone; they need to work together. This escalates the need for an environment where multiple devices will be able to communicate with each other in order to reap even greater benefits - cooperative processing may be the answer.

Because of the many advantages it offers, the PC/workstation is gaining momentum in the business world and becoming ubiquitous. We are now reaching the point where personal computers are powerful enough and inexpensive enough to create platforms that support a qualitative change in the way we work. We are entering an age where the average PC/workstation will far surpass the machines that used to be the hallmark of high performance. One of the critical components of this qualitative change will be cooperative processing. With the advent of cooperative processing and its ability to tap the latent power of the PC, the momentum created by PCs will be unstoppable. Certainly, one of the most rewarding computing challenges of the 1990's will be to utilize the PC/workstations to their fullest potential.

U.S. Consumption
Micros, Minis, and Mainframes

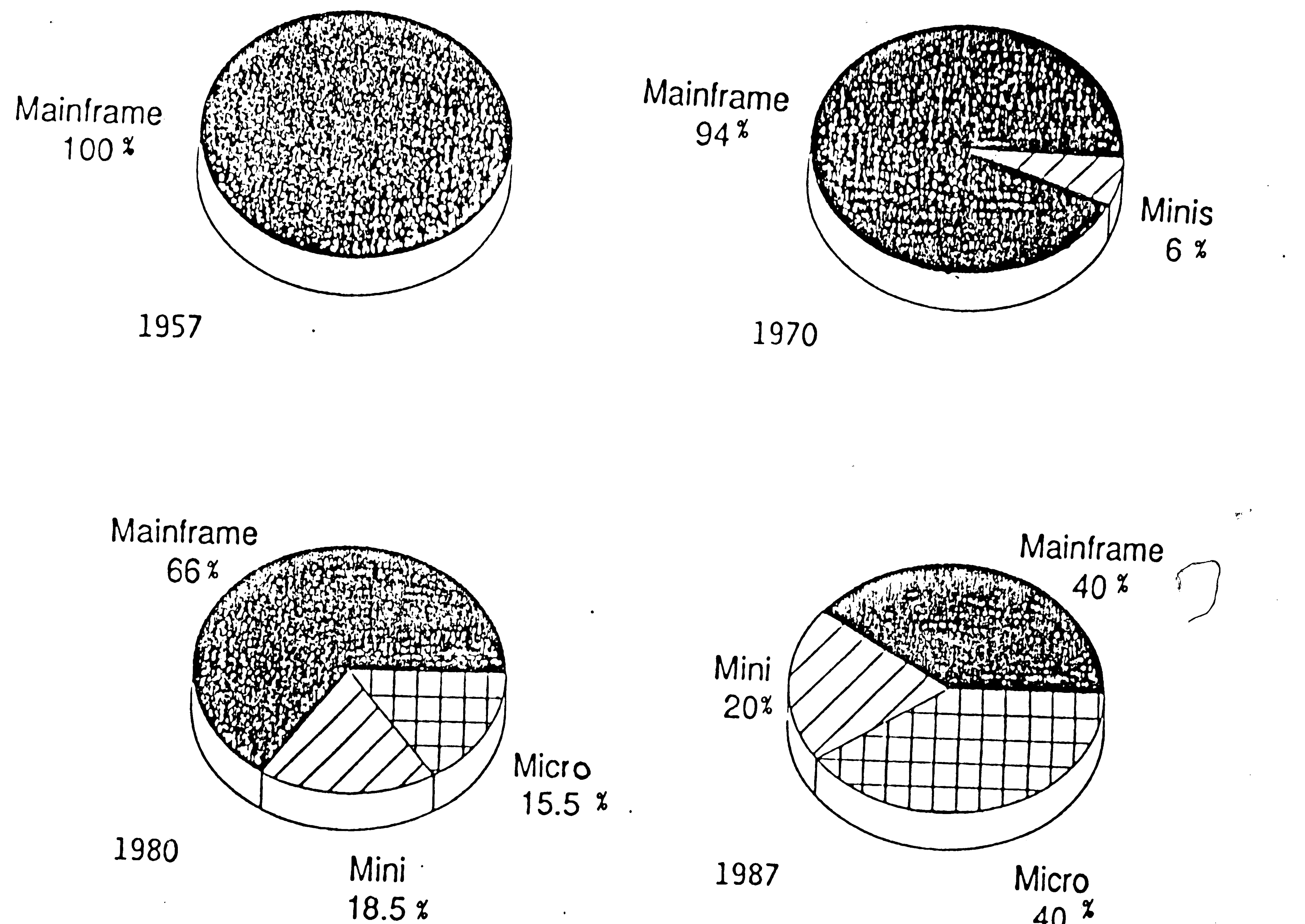


Figure 7

*Source - Datamation [15]

IDMS DASD UTILIZATION SUMMARY
JANUARY 1988

DATA BASE NAME	TOTAL CYL	PCT UTILIZED	CYL UNDER UTILIZED	CYL UNDERUTILIZED COST @1.88/MB/MO.	ANNUAL COST	PROD COPY
P001 TCS	60	56	8	$ 11	$ 964	PERM
P002 COST	5448	44	1416	$ 1896	$ 87510	NO
P003 MASTOR	471	52	85	$ 113	$ 7566	PERM
P005 RMS	2348	49	493	$ 660	$ 37715	YES
P006 CARMIS	1036	62	83	$ 111	$ 16641	YES
P007 SALESACCT	10	10	6	$ 8	$ 161	PERM
P008 PCRS	72	53	12	$ 16	$ 1157	NO
P012 SPEC GAS	1092	59	120	$ 161	$ 17540	NO
P013 VDTS	10	11	6	$ 8	$ 161	NO
P014 FAST RATE	221	49	46	$ 62	$ 3550	PERM
P015 LSE	351	48	77	$ 103	$ 5638	PERM
P018 RAGS	21	3	14	$ 19	$ 337	NO
P019 IDD	14	8	9	$ 12	$ 225	NO
P020 QA	73	39	23	$ 30	$ 1173	NO
P023 EMPLOYEE	160	21	78	$ 105	$ 2570	NO
P024 PGD	115	5	75	$ 100	$ 1847	NO
P026 GAS EQUIP	387	61	35	$ 47	$ 6216	YES
P027 APFREIGHT	719	5	467	$ 626	$ 11549	NO
P028 INSTRUMEN	527	2	358	$ 480	$ 8465	NO
P030 COMPLAINT	763	63	53	$ 71	$ 12256	NO
P031 SAFER	41	31	16	$ 21	$ 659	NO
P032 CSS	22	9	13	$ 18	$ 353	YES
P033 SALES PRO	1859	55	279	$ 373	$ 29861	YES
P034 CHEM RAW	27	3	18	$ 24	$ 434	NO
P036 MMS	564	63	39	$ 53	$ 9059	PERM
P038 PEDB	1641	42	459	$ 615	$ 26359	NO

Figure 8

C. Cooperative Processing Applications

The degree of complexity associated with the need to access and update data ranges from the most basic to the most complex. Through the use of a proposed new technology, cooperative processing, there will be many ways to develop applications that address these needs in varying degrees. In some ways, cooperative processing is not all that revolutionary, for it has been the basis for computer networking and distributed processing. Described below is a progressive approach to dispersed processing through the use of cooperative processing. By following this progressive approach, any amount of processing can be dispersed in varying degrees to the distributed processors in the network.

The simplest way to take advantage of cooperative processing within an application would be in the process of screen distribution, to offload screen processing for an application from the mainframe to the PC/workstation. Prior to displaying a screen to the user, the PC/workstation would intercept the screen image from the mainframe and alter its presentation. This type of application would transfer the human interfacing tasks from the mainframe to the PC/workstation and take advantage of the PC/workstation by offering better user presentation (color, windows, etc.) of data and providing simple validation of input. By making use of a better presentation mode, the system becomes easier to use, therefore the user can get more done in a given amount of time. This design would be most appropriate for data-entry applications, or applications where there is a high error rate or complex screens. Since basic validation is also available, (date validation, checking for non-numerics in numeric fields, etc.) additional savings may be realized in network usage and costs by using the network to transmit only data that has been error-checked and is ready to be processed. This type of architecture allows the PC/workstation to be used as little more than a terminal emulator. All data must still be stored and processed on the mainframe, with no sharing of data between the mainframe and the PC/workstation. The ability to provide new functionality without having to change any mainframe processing is a major benefit of this approach. Many organizations have not converted all of their terminal devices to PC/workstations, so they are not ready for a system that can only work with PC/workstations. This approach meets their needs by allowing a system to be created that will function as a cooperative system for those users that have PC/workstations, and will function as normal for those users that are still using terminals.

Although this type of cooperative processing application may be simplistic, it offers additional benefits over conventional processing in gained productivity and network cost savings.

A slightly more complex usage of cooperative processing in an application would be for data file management and transfer. That is, the ability to maintain and share data files on both the mainframe and PC/workstation, but with no real-time update capabilities for the PC/workstation. The data would be distributed to the local site that actually uses the data. However, there may be a need to validate some data against a master list. In this case the master list, maintained on the mainframe, could be transferred to the PC/workstation as a data table and used for validation purposes. This would provide for additional editing of data and error correction to be done on the PC/workstation. The only editing that could not be performed on the PC/workstation would be cross-file validations that are executed against files that are either too big or too volatile to be downloaded to a PC/workstation.

This type of application would allow some of the processing tasks associated with data validation to be transferred from the mainframe to a PC/workstation, eliminating costly CPU cycles associated with maintaining centralized files. This type of cooperative application would be most applicable in situations where data and the processing of data can be distributed, for example, an order-entry system in a regional office where only that site's customer data is needed to process information. But, we may need to validate product numbers downloaded from a table from the mainframe. After the data validation and local processing is completed, at some point in time, this locally processed data must be transferred back to the mainframe.

This is a slightly more sophisticated use of cooperative processing since you are now actively using both the mainframe and the PC/workstation for processing. It adds complexity because we must manage data changes on both the mainframe and the PC/workstation. Now we must know when things change on the mainframe, be able to send these changes to the PC/workstation, and be able to know that the PC/workstation has received the updates. In addition, we must determine how to transfer the data tables to the PC/workstation, establish some timeframe to update these table, and provide for the data transfer. This type of application offers benefits in the area of networks cost, above and beyond those offered by the screen distribution applications. Since there is data available from the mainframe, more validation can take place, causing a reduction in the amount of data being passed between the mainframe and the PC/workstation. Another benefit to be realized is that of autonomy. Now the PC/workstation can perform some individual functions and process data without the total availability of the mainframe, providing a benefit not only in the productivity of work, but also in the quantity of work that can be performed with the availability of the local processor.

The final and most complex applications to employ cooperative processing would require distributed, shared data. Data needs to be downloaded from the mainframe to a PC/workstation and uploaded from the PC/workstation to the mainframe, with the ability to update data in both places.

To utilize application processing in this fashion is the only true application of cooperative processing. All processors are allowed to function autonomously. Even though the mainframe may be down, it is still possible for an individual PC/workstation to continue operating normally. The rest of the architectures are still based on the master (mainframe) to slave (PC) relationship where the PC/workstation performs only a limited number of tasks and all of the major processing tasks are performed by, or supervised by, the mainframe.

In most cases, the primary database for an application should remain on a central processor where its security and integrity can be maintained. This allows the use of the currently available development tools and allows cooperative processing systems to be developed against the same databases that are used in conventional applications. Updates from the PC/workstation take place in real-time. There is no longer a need to batch data files and transport them to the mainframe at some later point in time. The same database technology can be employed on both the mainframe and the PC/workstation. For example, FOCUS databases could exist both on the mainframe and on the PC/workstation, allowing IS programmers to learn only one data manipulation language instead of converting from COBOL to a PC language.

D. Guidelines for Cooperative Applications

To a large extent, almost all applications would benefit from the utilization of cooperative processing. However, there are some applications that stand to gain more benefits than others because of their data and hardware requirements. Whether an application is being retrofitted to use this technology or a new application is being developed, it would be helpful to have some guidelines in determining which applications should take advantage of cooperative processing.

The first question that a developer will be faced with is "Is this application a candidate for cooperative processing?". In order to answer that question, it may be helpful to look at the type of applications and characteristics about it that would make it worthwhile to be considered a potential candidate for cooperative processing.

Those applications that are likely to incur high networking costs would benefit from cooperative processing. High networking costs are defined not so much the sheer volume of transactions, but those transactions that are executed frequently and also require a lot of data to be transmitted. Because of the human interfacing capabilities (presentation, color, error-correction, validation) that can be done on the PC/workstation rather than the mainframe, the volume of data being transmitted maybe reduced significantly. For those transactions that are executed many times but with little data to transmit, cooperative processing offers few savings, but when the volume of data transmitted via the communication lines is high and can be significantly reduced, cost savings can be realized.

The human interfacing capabilities now available on the PC/workstation through the use of cooperative processing, suggests two additional types of applications as candidates for cooperative processing. First, are those applications that require a high degree of operator intervention. A high degree of operator intervention requires the operator to look at the screen, understand the screen, and be able to supply values in a quick fashion. This is unlike data entry, where the operator does not have to look at the screen, but is keying from a piece of paper that looks exactly like the screen image. The second type of applications are those that have screens that have a high error rate because of field dependencies. Previously, if a field on a screen had to be validated, it had to be sent to the mainframe, validated there, then sent back down to the terminal if it was incorrect. Now, data tables can be maintained at the PC/workstation, so that when a field is entered it can be validated immediately, and transmitted only once to the mainframe.

Another potential candidate for cooperative processing are those systems that can be segmented so that a function within the system could be implemented in an autonomous fashion. For those systems that are too large to completely download to the PC/workstation, there is still the opportunity to download individual functions that could be executed without the availability of the mainframe.

A final type of system to be considered as a candidate for cooperative processing are those systems where users require functions that are available with standard PC software (e.g. graphics). This would enable the integration of PC software into applications, eliminating the need to unjustifiably write and debug programs on the mainframe that are currently available on the PC/workstation at a reasonable price.

Once an application has been selected as a potential candidate, because it fits the guidelines for the type of system that should be implemented as a cooperative system, additional consideration should be given to the data involved.

In determining what data to distribute in a cooperative application, we must pay particular attention to size, volatility, and frequency of access. With regard to size, large data files should be housed and maintained on the mainframe and not on the PC/workstation. Consideration should be given to partitioning the data so that some portion can be transferred to the PC/workstation, but not in its entirety. With regard to volatility, data that changes frequently should be housed and accessed on the mainframe. If it was housed on the PC/workstation, the user would either be accessing old data, or if an effort was made to update these tables on the PC/workstation everytime they changed, this would certainly increase the network usage and hence increase costs. Finally, data that are accessed only by a few users or on an infrequent basis should remain on the mainframe. It would offer no additional benefit to store and process this type of data on the PC/workstation, since the costs on the mainframe are already minimal. Ideally, cooperative processing can be best applied to applications with relatively small data files, low volatility, and a large number of accesses to that data - but no application is ideal. Therefore, many combinations of these three data characteristics could be considered as a possible candidate for a cooperative application (Figure 9).

Once a decision has been made as to what data to migrate to the PC/workstation, the next issue is to how to organize and access this data. For small single user applications, the entire application could reside on the workstation. However, cooperative processing most benefits a large, distributed application. In determining what data to use in an application, it makes the most sense to use data that can be partitioned. An entire large database application is obviously not appropriate to migrate to a PC/workstation. But that portion of the data that affects a particular site would be appropriate to migrate. Distribution of the data to a PC/workstation is the next consideration. The type of data to distribute falls into three categories: autonomous data, one-way data, and two-way data.

Autonomous data is that data maintained and used only on the PC/ workstation. This data should be organized as a local data table. It may be used to validate local zip codes, customer telephone numbers, etc. The use of local data tables offers several advantages. First, since this information is not applicable to any other location, it does not need to be stored on the mainframe. Second, since these tables are stored on the PC/workstation, access to the mainframe database for validation is eliminated. Finally, only valid data is sent to the mainframe. As a result of having all data available on the PC/workstation, there is very rapid response time because no mainframe cycles are executed. There are also no administrative issues to be concerned with in maintaining these data tables since they are site specific.

One way data should contain data that are applicable to all sites. They should be maintained on the mainframe, but available to each PC/workstation for retrieval and validation purposes. Because this data is somewhat general and volatile, it should be maintained on the mainframe. All the advantages associated with autonomous data apply to one-way data. One additional advantage is the savings of network costs. Since data is now transported to the PC/workstation, the PC/workstation can repeatedly access the data without any further I/O to the mainframe. However, there are some added complexities that must be addressed. Because we are now dealing with the transporting of data from the mainframe to the PC/workstation, administrative procedures must be established to effectively distribute this data. Procedures must be established to extract data from the mainframe, broadcast these changes to the PC/workstation users, transport the data to the PC/workstations, and finally to ensure that each PC/workstation has received the updates.

The final data to consider in data distribution is two-way data. Two way data deals with that data that is not only transported from the mainframe to the PC/workstation for retrieval and validation purposes, but also updated on the PC/workstation and sent back to the mainframe. Two-way data is best applied to those applications where it is critical to continue operating on the PC/workstation when the mainframe is down. There are now added complexities associated with maintaining this data. Since a lot of the processing is still done on the PC/workstation, all of the advantages of autonomous data still applies to two-way data, but the administrative issues become very complex at this point. Not only do the issues of transporting data from the mainframe to PC/workstation need to be addressed as with local data, but the transporting of data back to the mainframe must also be addressed. After updates are transported from the PC/workstation to the mainframe, the data should be deleted from the PC/workstation. But this can be done only after assuring that the update to the mainframe was successful.

A final area requiring guidelines for utilizing cooperative processing concerns the functions within an application. The most advantageous feature of cooperative processing is that it allows the participation of a PC/workstation in what was traditionally the mainframe arena. The ramifications go far beyond utilizing the PC/workstation to its fullest processing potential and extend to offering the PC/workstation a larger variety of software functionality. Suggested below are functions that would benefit most from the use of cooperative processing.

For systems that require user reporting, transferring this function to the PC/workstation is a good idea. One of the biggest limitations of mainframe databases is the ability to do ad-hoc reporting, because of the complexity associated with the mainframe tools that are available. By using cooperative processing, a programmer would write an extract program to transport the data to the PC/workstation. Then by using a user-friendly reporting package, users can access and massage the data in whatever fashion they would like. Also becoming available are PC packages that allow a user to design his own report format, no longer by using confusing reporting languages, but by designing the report as a screen.

Not only does this provide an advantage by offering additional and easier reporting capabilites for the user, but it also reduces costs, since these PC packages can be integrated in systems, and not rewritten on the mainframe. Also, there are functions that are available only through PC packages (e.g. voice and high resolution graphics) that now become available for integration for systems other than those that are PC-based.

A second function worth considering is browsing through multi-page text. By transferring this function to the PC/workstation, only one access to the mainframe database is required to initially obtain this information. All subsequent accesses will be done on the PC/workstation. Currently, paging on the mainframe is discouraged because it is expensive. Every page that is viewed, costs the user money. Therefore he is likely to view only the pages he really feels he needs to, and is reluctant to review data that may be important. On the PC/workstation, not only is there no cost associated with paging through text, even multiple times, but the response time is instantaneous.

A third function worth considering is multi-page updates. Cooperative processing offers both processing and psychological advantages in this area. When a person is working through a transaction, there are really only two times when slow response time is not really cumbersome. The first time is at the very beginning of a transaction, prior to starting the actual work, when data for that transaction is being gathered, and at the end of the transaction, when all of the work is completed and the actual update of data must take place - we call these closures. For a cooperative function that is initiated on the PC/workstation, there would be a closure to obtain the appropriate data from the mainframe. Once the data was transported to the PC/workstation, response time associated with updating and paging through the data would be instantaneous. Then there would be a closure at the end of the function for the data to be transported back to the mainframe for update. Somewhat slower response occurring only when the user is at an appropriate mental break point and expects it.

A fourth function worth considering would be validation and error-checking. This could be done on the PC/workstation by using autonomous data, without the rest of the database being available. If there are small groupings of data to be used for validation purposes, it would make sense to organize local data tables to validate information and save the network costs of transmitting erroneous data.

A fifth function that would benefit from the use of cooperative processing is windowing. If local table files are maintained on the workstation, when a field on a screen is invalid, instead of simply telling the operator that the field is in error and prompting for another value, a table (complete with all of the valid entries available) could be shown as a PC window, offering the user a finite set from which to choose a selection rather than to fumble for a valid entry. This windowing could be done on the mainframe, but the cost to develop, and the long response times associated with it make this feature on the mainframe prohibitive. The PC/workstation seems to be the obvious place to utilize this function.

A final function to consider when employing cooperative processing is when the optimal communication mode is graphical rather than syntactical. With the availability of graphics packages for PC/workstations being so extensive, it is both unnecessary and uneconomical to purchase additional graphics hardware and software for the mainframe when it is already available to the PC/workstations. Instead, it would be best to transport the data from the mainframe to the PC/workstation and use the graphics available at the PC/workstation.

DATA CONSIDERATIONS FOR COOPERATIVE PROCESSING

SIZE							
	SMALL	X			X	X	
	MEDIUM			X			
	LARGE		X				X
VOLATILITY							
	LOW	X	X			X	
	MEDIUM			X	X		
	HIGH						X
ACCESS FREQUENCY							
	LOW						X
	MEDIUM			X			
	HIGH	X	X		X	X	
COOPERATIVE APPLICATION							
	YES	X	X				
	POSSIBLY			X	X	X	
	NO						X

Figure 9

SUMMARY OF GUIDELINES FOR COOPERATIVE APPLICATIONS

- Applications that have:
  - High network costs
  - A need for increased understanding of screens through human interfacing capabilities
  - Segmented data
  - A need to integrate with existing PC software

- Applications with data that are:
  - Small in size
  - Low volatility
  - High access frequency

- Applications that require functions to support:
  - Ad-hoc reporting by users
  - Multi-page text browsing
  - Multi-page updating
  - Validation of autonomous data
  - PC windowing
  - Graphics

Figure 10

E. Potential Benefits

In order to better understand cooperative processing and how it differs from conventional architectures, it may help to understand those characteristics associated with it that produce benefits and help to build a case for it becoming the ideal processing system. Some of the critical areas in which cooperative processing offers advantages include: increased productivity, cost reduction, improved communication, and application functionality. There are significant benefits to be realized in all these areas for both the user community and IS.

Improved User Productivity

Technology is merely a tool, one we can use well or poorly. Because all tools require human creative energy to fuel them, applications must focus attention on the human effectiveness aspect of systems in addition to machine efficiency. To reach the next frontier of computer users, systems must be non-threatening to people who are not computer experts. Many people are intimidated and confused by computers.
We must realize that the future of computing lies in providing practical, easy-to-use tools that help people solve everyday problems. When the computer becomes second nature to use, then and only then, will

it gain wide acceptance. Just as there is no requirement for every automobile driver to be a mechanical engineer, not every computer user should be required to be an information specialist. With today's automobiles, a person with basic driving skills can operate one and travel to many places. In addition to basic driving skills, there are a few other things that help in the process of navigation that people take for granted, such as well-planned networks (highway systems) and easy to read user manuals (maps). This same approach cannot be applied to the computer. Using a computer often requires much studying of manuals, experimentation, and persistance. This example, more than anything stresses the importance of easy-to-use, efficient systems.

One benefit that cooperative processing offers users is a more efficient, therefore, more productive system. Screens can be designed to be provide a richer user interface, requiring less time per transaction. Because each strike of a key to initiate work on the mainframe costs the user money, developers are encouraged to put as much data as possible on one screen. As a result, these screens are difficult to read because they are too cluttered. The overcrowding of data leaves little room for field labels and instructions. Cooperative processing allows the developer to extend the same amount of data over multiple screens, allowing for clear labels and instructions to be added to the screen. Being able to use more screens within a systems without a cost penalty associated with it also encourages the use of on-line help screens within systems. With the availability of on-line help, time consuming error-correction cycles can also be eliminated. By providing more readability to screens and on-line help, systems will be made easier to learn and to use. Hopefully, this will not only increase the number of user-friendly systems available, but will also increase the number of people using these applications.

The emergence of the PC/workstation is directly responsible for many of the benefits to be gained from the use of cooperative processing. The PC/workstation's improved functionality can now be exploited within applications with many benefits to be realized. Screens can now be developed so that they are not only easily understandable, but when stepping through an application, the next step to take is also intuitive to the operator. By employing the PC/workstation for the human interfacing component of systems allows us to develop more understandable screens, and also minimizes the amount of typing that has to be done, since the use of icons to navigate through screens can also be employed. All of these can add up to a tremendous productivity gain for the user.

Another issue for improved end-user productivity is that cooperative processing supports local autonomy. As far as hardware, it limits the dependence on large and expensive computers. There is no more total reliance on a central site. Previously, if the mainframe was down, the entire system was unavailable. Now, the effects of a computer breakdown are confined to its point of occurrence. As far as data, cooperative processing provides for local data to be locally owned, managed, and accounted for. Since the processing of data remains at the local site, users processing local data are not penalized because of other users on the network. Local storage of data, therefore, decreases response time and communications costs and increases data availability.

Since no site depends on another for its successful functioning, each site will have direct control over its hardware, software, processing, and networking. With the hardware directly under their control, users can tune the computer for their specific organization's needs. This may also help to better manage their expectations by increasing their tolerance of adverse conditions. If response time is bad, they are more willing to accept it if they know they are directly responsible for it, but they are less tolerant if the problem exists because of other users on the network.

One last area of increased productivity for users is through the increased usage of existing information. Through cooperative processing, an organization can turn the corporate database from a static repository of information, into a dynamic corporate utility that is decentralized in its use.

Improved IS Productivity

The PC/workstation also offers developers the opportunity to improve productivity. Since most of the development in cooperative processing takes place on the PC/workstation, the facilities that make a PC/workstation attractive to a user (color, reverse video, windows, blinking, audible alarm), can also be built into the application development system and provide greater operator productivity. Development tools on the workstation are often easier to use than comparable tools on the mainframe. The interactive portion of an application can be developed faster and with less effort. The availability of PC/workstation tools for application development and testing, coupled with the constant response time of a PC/workstation, will do much for the improved developer productivity.

More effective screens can also have an impact on response time within a system. It eliminates the response time degradation involved with loading screens from the mainframe libraries and transmitting to a terminal. By transferring tasks such as screen handling, data validation, and application control to the PC/workstation, the amount of data sent to the mainframe is reduced, leading to a reduction in CPU consumption and communications overhead, and ultimately a reduction in response time. Since it allows the execution of the interactive part of the application to occur on the local processor, cooperative processing provides less variable response time and higher availability of a local dedicated processor.

Reduction in Costs

Additional functionality on the PC/workstation provides front-end processing for the mainframe, moving expensive machine cycles off of the mainframe and onto the low-cost PC/workstation. This can lead to considerable cost savings when you consider that the cost of one million instructions per second (MIP) on the mainframe is estimated to be approximately $160,000, compared to $4,000 on a PC/workstation (23). Because of the field validation feature available on a PC/workstation, cooperative processing can run applications more efficiently. The number of transactions executed can be reduced significantly by immediately flagging any incorrect input field and informing the user to correct it. As a result, only valid data are transmitted to the mainframe. This reduction in transaction volume can lead to considerable savings in CPU cycles.

The advantages in using a PC/workstation rather than the mainframe are significant. At the same time that we are employing more of the PC/workstation's resources through the use of cooperative processing, we are also making gains in the mainframe arena. Mainframe acquisition and support costs are quite high while the same costs for PC/

workstations are substantially lower. In addition, it is possible to expand in smaller capital increments - since PC/workstations can be purchased much less expensively than mainframes. If the mainframe becomes saturated, it is far more economical to acquire more PC/workstations and transfer CPU cycles to the PC/workstation, than it is to buy a new mainframe to provide additional computing power. By using the PC/workstation for field editing, table look-ups, and application control, the mainframe CPU consumption is reduced and mainframe efficiency increased. Reducing the mainframe CPU utilization will allow for the extending of the life of the mainframe, thus eliminating the need to purchase a new and expensive mainframe. By moving processing from an expensive technology to an inexpensive technology, cooperative processing allows an organization to realize considerable savings.

Improved Communications Requirements

The use of cooperative processing will help to reduce the growth rate of communication costs for organizations that have remote sites that need to communicate with the mainframe. The primary activity that the individual PC/workstation, rather than the mainframe, will be responsible for is screen handling. For example, Figure 11 provides a sample screen that is used in a maintenance management system to supply information about a piece of equipment. A simple analysis reveals the transmission of approximately 1100 bytes (300 bytes of data, 400 bytes for titles, and 400 bytes for addressing and attributes) of data over the communication line from the mainframe to the PC/workstation. Cooperative processing will still require a small amount of data to be transmitted between the mainframe and the individual PC/workstation, but since the screen now resides on the PC/workstation and screen transmission is no longer required, the amount of data to be transmitted will be minimal. This reduction of data will place the corporate network planners in a position to augment the current communication network. Most multi-drop strategies are designed for 50 percent utilization, which accommodates a maximum of five remote sites. By transferring the screen handling to the PC/workstation, line utilization will drop to approximately 10 percent, thereby allowing a greater number of remote sites to use the same leased line. Since this allows more sites per leased line, it may also be feasible to reduce the number of leased lines, resulting in additional savings. By reducing the amount of data that is sent, not only is there a reduction in traffic on the communication network and a reduction in the number of leased lines needed, it may also be possible to reduce costs on communication equipment. It may be possible to reduce the capacity of the network's multiplexers, modems, and concentrators.

However, this will not reduce the need for an efficient communication network. The need for cooperative processing is necessitated by the lack of reliability of the current communication networks. Cooperative processing will increase the PC/workstation's ability to use networks, printers, and mass storage at any node on the network. PC/workstations will be able to use the resources of any other computer or terminal on the network - capabilities in the past confined to mainframe and mid-range computers.

Improved Application Functionality

The ability to evaluate and analyze systems by business function, rather than at the application level provides many benefits, especially as systems evolve and new functions are desired. It can provide a way to easily upgrade existing applications with new functionality while significantly reducing resources. Specific assignment of tasks to a processor may vary from program to program within an application. Cooperative processing brings about the usage of multiple processors to execute a single transaction. The integration of the performance of tasks into all processing layers will be the building block of individual systems. By allowing this capability, many of the technological constraints of the current environment are overcome. This allows for enhanced functionality and also brings about other advantages. Not only can multiple processors be used, but it will no longer be necessary for an application to be developed in a single vendor environment. By supporting a multi-vendor, multi-product environment, cooperative processing will meet the increasing needs of users to operate in heterogenous computing environments - diminishing many of the incompatibilities between personal and larger computers.

Cooperative processing will also be instrumental in providing benefits to businesses by encouraging the development of strategic information systems that offer businesses a competitive advantage. Competitive advantage is not likely to stem from corporate systems such as payroll, accounts payable, etc., but rather from applications developed by the operating groups on PC/workstations. Projects utilizing cooperative processing will vary from company to company, and are underway now because information technology has been recognized for it potential to add value to products and services. Travel agents are on-line to airline, hotel, and automobile rental agencies, enhancing customer satisfaction by delivering immediate information and making reservations on the spot. Product distributors are increasing responsiveness by placing order entry devices at customer sites. Manufactures are communicating directly with suppliers via the computer to enable more efficient flows of material (16).

Strategic systems not only require product differentiation, but also the ability to change as business needs change. The market changes, business conditions change, customer expectations change, and technology changes. The challenges of a world economy require that information systems not only change, but change quickly. As companies restructure, acquiring new divisions and selling old ones, IS will have to integrate new information processing operations with those of the parent company. The more fluid design of applications through the use of cooperative processing will allow just that. Cooperative processing isolates the application from the information it processes, and will enable companies to restructure and access information on new servers with only minor changes. The ability to easily implement organizational and application changes will be instrumental for companies that need to stay ahead of the competition.

```
RM34AMAP
                    RESOURCE MANAGEMENT SYSTEM          23 JUL 88   13:03
                    OPERATIONS EQUIPMENT INQUIRY        PAGE:  1

FAC ABBREV: LAPORTE        1000 T/D A
FAC CODE: LD   PLT CODE: 10
TAG NO 01.10
SYSTEM  MAC                    DESCRIPTION MAIN AIR COMPRESSOR
CLASS - MECHANICAL   CATEGORY - COMPRESSOR, CENT        TYPE - POSTER

PROJECT  00-6-5752        SERVICE AIR
PO NO                     SPEC NO 00-6-5752-01.10-01A     KEYWORDS      - Y   (PF1)
                          USED ON                         SPARE PARTS  - Y   (PF3)
                                                          NOTES         - N   (PF10)

MFR ABBR - HITACHIAME     0012343
    NAME - HITACHI AMERICA, LTD
MFR MODEL- 1DHB-6H (DH-112)
    TYPE -
NOTES:

PF1 KEYWORD INQ/GRP: DC
PF5 - WHERE ELSE USED    PF9-TAG HELP        PF3-SPARE PARTS LIST
                                             PF12-RETURN              HELP:
```

Figure 11

SUMMARY OF POTENTIAL BENEFITS

- Improved user productivity
- Improved IS Productivity
- Reduction in costs
- Improved communications requirements
- Improved application functionality

Figure 12

III. Implementation of Cooperative Processing

The process of developing information systems has been time-consumming and demanding. As with other recent technologies, the early days were characterized by hap-hazard approaches as individual developers experimented with their own ideas, each in a separate direction. This resulted in a series of project failures. The real problem was neither the people nor the technology, but the lack of planning.

The impact of the changes on the current environment resulting from the implementation of cooperative processing makes it essential for organizations to develop an implementation plan. Because of the profound impact that cooperative processing will have, it is best to implement using an evolutionary approach. A three stage approach is suggested: 1) education, 2) passive implementation, and 3) active implementation. The key activities in establishing a framework for the successful implementation of cooperative processing will be preparation and planning.

Stage 1 - Education

The first stage of implementing cooperative processing is to develop an understanding of the technology and to appreciate its capabilities. Although the concept of cooperative processing is probably one to two years away from mainstream use, corporations should begin to understand the concept of this technology. It would behoove most organizations at this point in time to begin to investigate the products that are currently available. In addition to the management of the introduction of new software technology, there are other infrastructure requirements that need to be considered: IS personnel training and development, communication and network impact, and associated costs. By understanding all of these issues, an organization will be better able to determine the positioning required prior to implementation.

After a thorough understanding of the proposed technology, each organization must decide whether or not it is advantageous to proceed to the second stage. Some factors worth considering in this decision are available resources and the portfolio of applications. For those organizations whose manpower and monetary resources are limited, it may make sense to remain in stage 1. Also, an organization should review its portfolio of applications in respect to its overall strategic plan. If there are no applications that offer strategic advantages to the corporation at the current time through the use of cooperative processing, then perhaps it is best to play the waiting game and allow others to make mistakes and learn from their experiences in this new technology. Taking this approach minimizes the risks associated with implementing cooperative processing, but also minimizes and delays the the benefits to be gained.

For those organizations that do remain in stage 1, it will be important for them to stay abreast of advances being made in the industry. One person, or a small team, should be assigned this task of keeping current of industry advances and communicating this information with the rest of the company.

Following is a list of suggested activities that comprise the framework for a stage 1 implementation.

1. Read and research articles in the trade press
2. Establish software selection criteria
3. Investigate products available
4. Assess the usage of cooperative processing in accordance with the strategic plan
5. Assess the infrastructure requirements
6. Establish a timeframe for exploiting cooperative processing
7. Select a software product

Once an organization feels comfortable with the technology and has made a commitment to proceed with the implementation of cooperative processing, it can advance to stage 2 - Passive Implementation.

Stage 2 - Passive Implementation

Passive implementation involves the integration of cooperative processing into existing applications. The increasing popularity of

PC/workstations makes this stage a viable option. Personal computers are becoming the standard workstation in the business place. By combining the technology of both cooperative processing and the personal computer, existing systems can be enhanced with much richer functionality. Today there are many personal computer users in industry and government who would like, but cannot get, access to the high-quality, high-volume computer graphics that mainframe users are now receiving. They have several choices: they can dispose of the personal computers and get terminals to connect to the mainframe; they can purchase graphics hardware and software for each of the personal computers; or they can try to incorporate cooperative processing.

In light of the human interfacing capability of the personal computer, it may be advantageous to use a PC/workstation for the screen handling tasks associated with an application. This is a somewhat limited, although perphaps more feasible use. It may not be possible to forge full steam ahead, since cooperative processing will require a PC/workstation and not simply a terminal. Because of cost considerations, most organization will elect to replace terminals by intelligent devices on a gradual basis. Passive implementation of cooperative processing offers the advantage of using this new technology only where PC/workstations exist, and to continue processing as usual where terminals are still being used.

In most mature organizations, there exists a large installed base of applications, consisting of transaction-driven systems, rather than strategic systems. To abandon these systems and start with new systems would not be economically feasible. In this type of environment, using cooperative processing passively would not only allow the continued use of these existing systems, but would also offer a processing advantage. Most benefits from employing cooperative processing will result from reduced operating costs, as a result of performing far fewer transactions on the mainframe for the transaction-driven systems. By leveraging the power of the PC/workstation and changing the existing systems, some benefits in the operating environment can be gained: reduced operational costs (largely due to error correction on the PC/workstation) and improved operator productivity. Another intrinsic benefit will be the knowledge gained through experimentation, providing a foundation on which to build additional cooperative systems.

Organizations looking to gain processing advantages through cooperative processing should begin to develop hands-on experience with this technology in order to verify and quantify benefits while identifying system design, administrative, and other infrastructure issues. Hands-on experience will require the dedication of personnel (a project team) to actually perform the implementation. Although advancing to stage 2 offers potential benefits by passively using cooperative processing, it also has more risk due to the preparation associated with it. There will be more preparation necessary to develop an implementation plan since there will be additional people and activities that must be managed.

Following is a list of suggested activities that comprise the framework for a stage 2 implementation.

1. Select an appropriate application to retrofit
2. Form a project team
3. Identify objectives and benefits
4. Establish benchmarks so results can be quantified and benefits measured
5. Install software
6. Document results
7. Communicate results to the organization

For many organizations, stage two may be an iterative process for any one of numerous reasons. First, the selected software may not be appropriate. It may have been too difficult to learn, performance may not be what was anticipated, or it simply did not fit well into the current environment. Because cooperative processing is a technology in early development, better products may be continually appearing on the market. Early in the development of new technologies, products debut that are appropriate for prototyping and experimentation, but not production applications. It may take some time before vendors can develop and support products robust enough for production applications. In addition to cooperative processing software, the application chosen to retrofit may not have been appropriate. Second, the IS organization may not be prepared to deal effectively with this new technology. There may exist a need for further training requirements of IS personnel. Third, cooperative processing requires a platform of personal computers, and too few may currently exist to make cooperative processing advantageous. Fourth, the incremental amount of risk associated with implementing cooperative processing may not be justified by the benefits that will be achieved.

When an organization has achieved success in stage 2 and is ready to undertake additional risks for additional benefits, it can proceed onto stage 3 - active implementation.

Stage Three - Active Implementation

The third stage of implementation involves more than merely utilizing a PC/workstation as a screen handler, but involves the active participation of the PC/workstation in the application processing. This phase goes beyond the uses described in stage 2 (the retrofitting of existing applications for screen handling) and provides for an entire systems to be developed with cooperative processing. Through cooperative processing,the PC/workstation and the mainframe will share processing functions. Organizations opting to continue implementation to stage 3 should be those who have reviewed their application portfolio and stand to gain a competitive advantage by getting into the market place first. For example, Avis has already begun to use a cooperative processing application in their car rental business. Since Avis offers a non-unique product at a comparable cost across the industry, the one thing that Avis can offer to distinguish itself from its competition is service. Its new system provides up-to-date contract information instantaneously and ensures a complete and accurate receipt. Now customers can receive better service, spend less time in lines, and get billed accurately. If the process of renting a car is made much more simple and accurate through one company than through any other, there is little doubt which company will out perform the others.

Advancing to this stage, an organization has the opportunity to increase benefits, but once again, benefits do not come without associated risks. This stage poses the most risk to organizations because of the amount of preparation that must take place prior to implementing cooperative processing. The interaction of both the PC/workstation and the mainframe in this stage, poses many additional issues and concerns that must be addressed.

In the mainframe environment, the major issue that must be addressed is the impact on the current environment. Especially in larger shops, it will be important to identify new releases of software required for compatibility with the cooperative processing software chosen. Installing new releases of software can be an extensive effort, complicated by the sheer number of software packages installed at an organization. Therefore, identifying these changes and establishing an implementation plan for installation will be critical.

The large majority of issues and concerns that have to be managed in this stage will be in the personal computer platform. Many changes will have to take place since PCs are no longer being utilized strictly in standalone mode, but as a PC/workstation in an integrated system. Many issues that once had to be addressed and reconciled with the mainframe, now have to be addressed on the PC/workstation. The first issue is security. As companies replace terminals with PC/workstations to allow mainframe access to help mitigate the data processing burden, the potential for security problems and risks increases. Once safely confined to a computer center, computers are now appearing just about everywhere. No longer can all hardware be safely locked in a room with limited access. Will the current corporate security package be adequate or will new interfaces need to be written for the PC/workstations? Along with security goes the issue of auditability. On the mainframe, object modules are secured in protected libraries, which do not currently exist on the PC/workstations. In addition, some thought should be given to instituting change control procedures on the PC/workstations to increase auditability. Because developers on the

PC/workstations will be interacting with other PC/workstation and mainframe developers, development standards must be established in the PC environment. There is a need for PC standards, but they have to be flexible enough to aid in creating and delivering applications that are capable of change. It will be important to standardize, but not to ossify.

Following is a list of suggested activities to comprise the framework for a stage 3 implementation.

1. Select an appropriate application
2. Add breadth to existing project team to include people from the development area
3. Begin incorporating cooperative processing requirements into the current environment and capacity planning activities
4. Begin incorporating cooperative processing requirements into the hardware and software selection process
5. Continue to closely follow developments in the marketplace

This evolutionary approach promotes learning through experimentation. For, it is through trial and error that knowledge is often best acquired. The more advanced stages to which an organization is willing to advance, the more knowledge and understanding it stands to gain. By remaining in stage 1, risks are minimal, but so are benefits. By progressing to stage 3, the risks increase, but so do the benefits.

Each organization must individually assess the potential risks and benefits associated with the implementation of cooperative processing and chart its own course through each stage. Keep in mind that there is no hard and fast rule as to the length of time that an organization will spend in any one stage, since that will be driven by each organization's strategic plan.

IV. Cooperative Processing for Maintenance Management

Computers are being employed more and more, and are improving the way that companies are being managed. Much automation has been applied to adminstrative tasks within corporate offices with many benefits acquired. However, particularly within manufacturing companies, technology is not only improving the ways that corporate offices are managed, but the way that plants are managed too. Prudent managers recognize that maintenance of plant systems and capital equipment is essential. The techniques of maintenance are well documented and the practice of maintenance management, in one form or another, is nearly universal. However, within the area of plant maintenance lies a significant opportunity for performance improvement. Though not the sole solution to maintenance problems, maintenance management information systems can enhance the efficiency of a well structured maintenance management program.

One Fortune 200, large manufacturing company has developed a maintenance management system called Resource Management System (RMS). RMS provides an online system to collect equipment data, provide for the maintenance of that equipment, and to store that information in an integrated database on the mainframe. Designed in the early 1980's and implemented in 1982, RMS was at that time a state-of-the-art maintenance system. However, as technology evolves and the usage of the system increases, the users are beginning to make additional demands upon the system,changes to which a mainframe oriented system cannot respond. The users dissatisfaction stems from the limitations of the mainframe. First, because RMS is a mainframe system, when the mainframe is down for preventive maintenance, the RMS database is also down and unavailable for the users' needs. However, the operating plants are in operation twenty-four hours a day, seven days a week, hence plant personnel still need access to critical data that is stored on the database, and they will not tolerate outages on the mainframe. Second, as more and more mainframe database systems are developed, response time continues to become slower as costs increase. When approached by the users for solutions to these inherent problems, cooperative processing was suggested. A proposal to initially interface one existing function from RMS with cooperative processing was recommended, so that improvements to the current system could proceed in a controlled fashion with ample time to evaluate the technology before forging ahead.

The first task that was faced was the selection of a function within RMS that could be a potential cooperative application. By following the suggested guidelines (Figure 12), the processing of worklists was selected. By definition, a worklist is a task or group of tasks that specifies some maintenance work that must be performed to a piece of equipment at a plant. The reasons for selecting worklists as an appropriate function for a cooperative processing application are as follows:

1. High Networking Costs

   By referencing Figure 13, we can readily see the amount of data that is involved with processing a worklist. There is a lot of data that has to be transmitted from the mainframe to the terminal and back again, causing high volumes of data, hence high costs.

2. Human Interfacing

   Not only is there a lot of data that contributes to the network costs, but the screens are cluttered and difficult for the operator to understand and navigate through currently.

3. Segmented Data

   Processing a worklist is really a distributed, not centralized function, since it involves the processing of autonomous data. Worklists describe tasks that must be performed on a specific piece of equipment at a specific plant. The performance of these tasks involves one, and only one, plant. While the results should still be stored on a centralized database to allow for trend analysis and problem detection, the data and the processing of it should be distributed.

4. Access of Data

When considering frequency, size, and volatility, worklists match the criteria for all three functions. Worklists are generated on an infrequent basis, compared to most typical on-line transactions. Instead of being performed many times a day, these transactions are typically generated only at the beginning of the month. Relatively small worklists are generated by each plant manager on the first of every month to ensure that the performance of all monthly tasks is completed. Since each plant manager generates worklists for his own facility, the size of the worklists is small and manageable since it involves work for only one specific plant. The data selected for a worklist is static, and cannot be changed once a worklist is generated. Therefore, the data is retrieved once from the mainframe, then processed at the PC/workstation, and finally, when all tasks have been completed, update the mainframe.

5. Ad-hoc Reporting

A large amount of operating data is collected through the performance of monthly tasks. However, it is stored in the mainframe database, which is too unwieldy for users to understand reporting languages and extract information. By providing access to the data on the PC/workstation, users can use PC packages, designed with ease of use in mind, and users can finally gain access to valuable information on their own.

```
NPW3AMAP                     MAINTENANCE WORKLIST              01 AUG 88     10:39
                               ACTIVE WORKLISTS                 PAGE    1
FAC ABBREV: CONVENT     750 T/D-B
FAC CODE: FK PLT CODE: 02

   SELECT A WORKLIST FROM THE LIST BELOW:

S   # OF TASKS                    NAME                           DATE SAVED
           0       NORMAL PM FK-02 ALL CLASSES                    06 JUL 88
          33       MECH-D-SEP88-VGH                               16 JUN 88
         169       INSTR-D-SEP88-VGH                              16 JUN 88
          91       ELEC-D-SEP88-VGH                               16 JUN 88
           0       1988 TURNAROUND B PLANT                        07 JUN 88
           0       JUNE PM FOR ALL CLASSES                        03 JUN 88
          36       PM FOR ALL CLASSES NORMAL                      03 MAY 88


STD PAGING
PF2-COPY CRITERIA
PF3-WORKLIST INQUIRY           PF5-PRINT WORKLIST         PF8-MODIFY WORKLIST
                               PF6-DELETE
```

Figure 13a

```
MPW5AMAP                  MAINTENANCE WORKLIST                  01 AUG 88   10:40
                                INQUIRY                          PAGE  1
 FAC/PLT: FK 02  CONVENT      750 T/D-B
                                                                 SYSTEM:
WORKLIST NAME: MECH-D-SEP88-VGH                                     CLASS: MECHANICAL
                                                                                    DUE
!     ID CLASS/LOOP/TAG TASK NO.   TASK NAME                     FREQ TYP MANHR SKILL DATE

      C MECHANICAL           5838 OCAC HEAT EXCH.-REMO              F O   48.00 ME 13JUN88
      C MECHANICAL           5841 MOLE SIEVE DRIERS- C              F O   32.00 ME 13JUN88
      C MECHANICAL           5045 REPAIR 'AR-15' LINE               F O   24.00 ME 13JUN88
      C MECHANICAL           5047 SOLDER L.P.COLUMN 2"              F O    6.00 ME 13JUN88




STD PAGING   PF2-TASK LIST (HOURS)       PF3-TASK PAGE TWO
```

Figure 13b

```
MP66AMAP                  MAINTENANCE WORKLIST      - INQUIRY     01 AUG 88    18:41
                          REVIEW TEXT OF SELECTED TASKS           PAGE  1 OF   1
TASK NO:     5838         NAME: DCAC HEAT EXCH.-REMOVE INSULATION RINGS
CLASS: MECHANICAL         LOOP:                                  TAG:
                         CATEGORY:                              TYPE:
  MFG:                   MFG TYPE:
 ABBR:                      MODEL:
                          SERVICE:
    TASK TEXT:
          REMOVE RINGS USED FOR ATTACHING INSULATION
          -DOES NOT REQUIRE PLANT SHUTDOWN-
          -MAY BE COMPLETED PRIOR TO OUTAGE-




 FORWARD PAGING     PF2-TASK PAGE TWO                                PF12 - RETURN
LANGUAGE: ENGLISH
HIT PF2 TO SEE TASK PAGE 2
```

Figure 13c

```
MP76AMAP          MAINTENANCE WORKLIST      - INQUIRY    01 AUG 88    18:42
                   PROGRAM TASK PAGE TWO INQUIRY

TASK NO: F    5838      NAME: DCAC HEAT EXCH.-REMOVE INSULATION RINGS
CLASS: MECHANICAL       LOOP:                           TAG:

            THE FIELDS LISTED BELOW ARE REQUIRED FOR ALL TASKS
            PLEASE REVIEW THE DATA, THEN SELECT A FUNCTION.

            PRIMARY SKILL REQUIRED       11     MECHANICAL
            MANHOURS REQUIRED            48.00

            TASK TYPE                      NORMAL
                                         X DOWNTIME

            NOMINAL FREQUENCY               YEAR             DAY
                                            MONTH            REFERENCE
                                            WEEK

PF1 - TASK TEXT
PF2 - REVIEW PAGE TWO DETAILS
```

Figure 13d

```
MP06AMAP          MAINTENANCE WORKLIST      - INQUIRY       01 AUG 88    10:42
                   PROGRAM TASK DETAILS INQUIRY

TASK NO: F    5838       NAME: DCAC HEAT EXCH.-REMOVE INSULATION RINGS
  CLASS: MECHANICAL      LOOP:                          TAG:
                  S CDE  SKILL                HOURS S CDE  SKILL              HOURS
REQD SKILLS       X 11 MECHANICAL             48.00    12 INSTRUMENT           0.00
AND MANHOURS        13 ELECTRICAL              0.00    14 OPERATOR             0.00
                    15 ADMINISTRATIVE          0.00    16 CONTRACTOR           0.00

PERFORMANCE WINDOW  FROM:        TO:               EXPIRATION DATE:
                 PRIORITY:     (1,2,3)             TIMES REPEATABLE: N (1,2,3,N)
            FEEDBACK TYPE: C   (M,C,FF)            STATUS: ACTIVE
           RESPONSIBILITY:                         LOCATION:
               ENTERED BY: A4197                   DATE ENTERED: [illegible]

[illegible] PF1 - FEEDBACK FORMS                      PF6 - [illegible]
[illegible] PF2 - SPARE PARTS                         PF7 - RETURN TO PAGE ONE
[illegible] PF3 - SPECIAL TOOLS                       PF8 - [illegible]
[illegible] PF4 - MAINTENANCE PROCEDURES
[illegible] PF5 - NOTES
```

Figure 13e

MPC4AMAP

PM TASK COMPLIANCE
TASK LIST

01 AUG 88 18:56
PAGE 1

FAC/PLT: FK 02 CONVENT 750 T/D-B

SYSTEM:

WORKLIST: 880616114311 NAME: MECH-D-SEP88-VGH

CLASS: MECHANICAL

C	ID	CLASS/LOOP/TAG	TASK NO.	TASK NAME	DATE LAST PERFORM	ACTUAL MANHOURS	PERFORM BY	DATE PERFORM
	C	MECHANICAL	5838	DCAC HEAT EX				
	C	MECHANICAL	5841	MOLE SIEVE D			A2212	01AUG88
	C	MECHANICAL	5845	REPAIR 'AA-1				
	C	MECHANICAL	5847	SOLDER L.P.C				

[illegible] PAGING PF2-UPDATE COMPLIANCE [illegible]
[illegible] TASKS UPDATED

Figure 13f

The proposed software for developing this maintenance management application is Super-Link, developed by MultiSoft Inc., Lawrenceville, New Jersey. The reasons why this software was selected are as follows:

1. Hardware Compatibility

   Super-Link enables an IBM or compatible PC/workstation to participate on a peer-to-peer resource sharing basis with its host.

2. Software Compatibility

   Super-Link requires no changes to be made to existing mainframe software. It consists of the vendor's software residing on the mainframe and the PC/workstation, and uses its own protocol for data transmission.

3. Network Compatibility

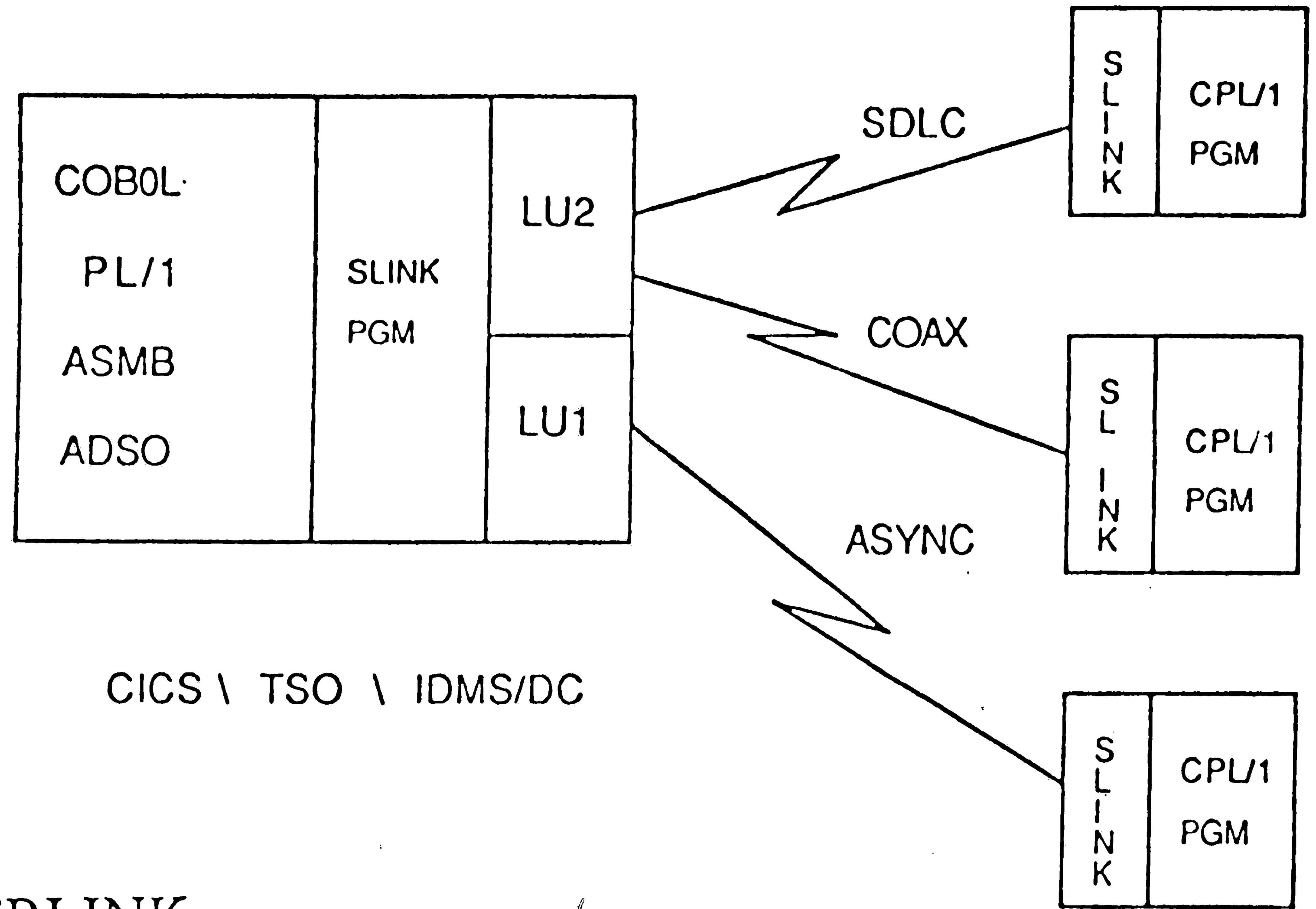
   Super-Link uses the existing SNA network protocol.

4. Functionality

   Super-Link allows the integration of many devices such as micro/mainframe links, host based virtual disk facilities, and a set of developer tools.

Refer to Figure 14 for a proposed product architecture.

PRODUCT ARCHITECTURE
MULTI SOFT



- SUPERLINK
  - PC: SOFTWARE - SUPERLINK
    - APPLIC. INTERFACE - CPL/1 (PROPRIETARY 4GL)
    - CONNECT - COAX, SDLC, ASYNC
  - HOST: SOFTWARE-CICS/VS OR TSO OR IDMS/DC
    - APPLIC. INTERFACE - ADSO, COBOL, PL/1, ASMB.

Figure 14

*Source - R. Krikorian [11]

V. Impact on Information Services

A. Impact on IS Organizations

Changes in data processing requirements and technology have made it necessary for the IS organization to adapt and change in the past. While it is evident that the IS function is in transition toward a new mission and structure, there is much ambiguity over what the IS organization will look like in the future (7). With the fast approaching emergence of new technology, the only way for IS organizations to survive will be to adapt to these profound changes.

In many corporations today, the IS organization exists as a service organization, charged with functioning efficiently, recovering costs, and providing reliable service. IS does not have to be a passive observer when it comes to technological innovation, although many IS organizations do. And they exist today because of the data and processing requirements on the mainframe, the monopoly for computing services that IS used to have within a company is being challenged by a developing service market both inside and outside of the corporation, and poses a threat to stagnant IS organizations.

The IS organization is being charged with the identification, development, and implementation of applications to solidify competitive advantage - applications introducing new dimensions of complexity and risk. IS organizations will need expand their development of systems from traditional systems that support the company, to strategic and competitive systems that will enhance revenue generating functions. Failure to become a value-added supplier of services, will surely lead to the demise of any IS organization. The introduction of cooperative processing as a tool to help develop a competitive advantage seems to be one of the driving forces behind this new IS mission. The applications that will result from this new technology will need to be designed and implemented in new ways, bringing about changes to both IS and user organizations.

Just as the philosophy of various processing layers functioning peer-to-peer with one another is applied to technology, this same philosphy can be applied to people and organizations. The master (IS) to slave (user) structure that previously existed is changing. In the early days of corporate computing, IS owned all of the hardware, developed all the software, and was totally responsible for all processing that took place on the computer. Up until 1980, the dominant form of information technology at large companies was internal data processing - mainframes and centralized management. This era, a necessary period of building during which evolving information technology was grafted into the existing organizational structures, at best had only a tactical impact on the overall organization. The IS department emerged as a well-managed, standalone information service department, providing a strong foundation upon which to build for the future.

Today, as a result of all the technological changes being made, both IS and user roles are being modified. Traditionally, IS and their users had been isolated from one another. As far as most application development efforts went, IS has played a service-oriented role, meeting with the users at the onset of the project to define the requirements, and at the completion of the project to deliver the final product. All of the analysis and development work for a project was the total responsibility of the IS organization. However, as users become more productive, emphasis in the IS department must shift from trying to do all the work, to consulting to users in their own work. Additional consulting services are being called upon by the user as they purchase more package software. A mission based on integration with the users is a must in order for IS to effectively add value. IS must broaded its understanding of the business as a whole. As cooperative processing forces technology into the business functions, business concerns become more important to IS. Traditionally, IS priorities have been toward the management of information technology first, and the management of people second. Too often business has been a distant third. IS executive must recognize the importance of a business orientation and focus on business skills in addition to technical skills. IS will still actively provide a service role, the major difference will be increased user involvement. Working more closely with the users, IS will not only be called upon as technical consultants, but as business consultants as well. IS organization must be able to translate business plans into information technology implications. User management will continue to be instrumental in identifying applications, but IS, acting as consultants to the business units, will provide information for the need and the value of the proposed applications. It will be important for IS to take neither a totally passive, nor totally dominant role in directing an organization's information processing activities. A balance should be sought between these two extremes, for it is through this balance that IS will be able to make its most significant contributions.

These required changes cannot happen overnight. Users do not yet have the technical knowledge to match systems with needs, nor do they have the experience to develop applications. Therefore, the IS organization must continue to provide a strong advisory and support role.

B. Issues for IS Management

IS management must move forward decisively to lay the groundwork for their companies information strategies. The management issues to which IS executives must be most attentive are: rapidly accelerating decentralization of corporate computing power; emerging demand for computer-to-computer communications; the steadily rising plateau of user-level processing capability; the need, in light of modern IS approaches, to readjust the concept of the corporate database, and, again, in view of changing information strategies, the need to review and redirect as needed the responsibilities of the corporate IS function (7).

With the barrage of the PC/workstations over the past five years, the challenge of an effective personal computer platform is becoming an increasingly important item for IS organizations. Personal computer users have achieved independence by taking control of their own applications, proving to IS that they could accomplish a great deal on their own. Now that users are actively involved in day-to-day data processing, it has become necessary for IS management to take charge of the situation and direct long-term strategy. With more and more emphasis being placed on decentralization and individual PC/workstations, IS management must develop a strategic plan which includes the PC platform. The success of cooperative processing relies heavily on the successful integration of the PC/workstation into the business place as a processor of production applications. Therefore, IS management must stablize the personal computer platform by developing and adopting PC standards.

As the useful life of the stand-alone PC/workstation continues to wane, a policy concerning the growth and usage of PC/workstations must be established. Top management must realize the benefits of PC/workstations functioning together and establish an approach for designing and implementing PC/workstations in the network. Distributed, on-line processing is the way of the future. IS organization have many issues to deal with in addressing the PC/workstation and the technology it empowers as it becomes an integral part of the corporate computing environment.

Since cooperative processing will ultimately involve a multi-vendor environment, standards must be developed to provide a framework that makes multi-vendor communications possible. IS must establish standards in the following areas: user interfaces, database accesses, local area networks, and communications. In the past each computer vendor defined a unique way of communicating between computers and terminals. Today, computers must be able to communicate and share information with all other corporate computers. Adherence to these standards will allow users to effectively manage and share information. Standards will provide users the ability to grow and change as their business needs change, while at the same time they can protect the investment that already may have made in multi-vendor hardware.

This connectivity trend will dominate the tactical planning in many IS organizations. Connectivity of increasingly decentralized computer applications must be organized. Since technical barriers no longer exist, there is a need to move more aggressively in this area. IS will be responsible for the technological infrastructure within an organization. The strategic planning for IS will include the responsibility for a long-range architecture plan, which is becoming a more and more important issue because of PC/workstations and cooperative processing. IS must specify corporate wide architectures and standards for networking, connectivity, applications development tools, database strategies, and security.

The most significant challenge IS management will have to face is the introduction of cooperative processing into the organization. A variety of issues exist in this area that will need to be resolved. First, IS management must convince users that cooperative processing is the way of the future and that projects utilizing this technology should be developed. Realizing, that although it may be easy to justify applications that meet tactical goals and achieve short-term benefits, it will be much more difficult to justify funding for projects that will not show a payoff for several years. A second challenge that IS management will have to to face is the acceptance of cooperative processing into the system development process of the IS organization. How will they encourage developers to use cooperative processing? In most large organizations, a majority of the IS developers are PC illiterate. Having directed all of their development efforts towards the mainframe, their skills and knowledge also lie with mainframe technologies. Because these skills and knowledge are often hard-won, they are not always easily abandoned. Part of the solution to this challenge may be the third issue to be addressed, that is the education and development of the IS professional, as well as managing the changes they are experiencing. It is often difficult to bring a new technology into an organization because people now have to venture beyond the technologies with which they are familiar and comfortable. The IS professionals will have to be convinced that the knowledge and experience they have worked long and hard to gain will not be wasted, but rather, that it can be applied towards a new technology. Proper education and training will be essential. If neglected, both the morale of the IS organization and the usefulness of IS to the company will suffer.

The evolution of computer technology is approaching so rapidly and diversely with the availability of powerful desktop PC/workstations, cooperative processing, fourth generation languages, and high speed networks, that today's IS managers must be certain that they have a qualified and agile staff to use these technological tools.

Finally, IS management must also consider the impact that cooperative processing will have on the IS strategic plan. The IS application profile must include a combination of experimentation with leading-edge technologies and pilots of these latest available technologies. Management must encourage experimentation and support it with corporate money and people. For without experimentation today, an IS organization will not be ready to support implementation tomorrow.

C. Impact on the IS Professional

A recent survey of Fortune 1000 executives indicates that as information technology becomes increasingly decentralized, the ability to adapt to new professional roles will displace sheer technical talents as the key to career success for IS professionals. Changes in technology will have an impact on the IS professional's role, responsibilities, skills, and job description (9). Since data processing requirements have changed so much over the years, it has been necessary for the IS professional to become proficient in learning, accepting, and understanding new technologies. The continuing rapid evolution of technology means that the IS professional must continue learning and maintaining his skills.

Since the transition from batch to on-line processing occurred in the early 1980's, little has changed in the day-to-day life for the IS professional. Over the past five years, most IS professionals have been applying the same skills, allowing them to become experts in the technology currently at hand (on-line, interactive systems). Just as switching from batch systems to on-line systems required a new set of skills to be learned, cooperative processing will require additional skills to be added to their skill set.

Cooperative processing represents comprehensive changes in the skills necessary to design, implement, and maintain applications. Currently, most production applications are designed and developed on the mainframe. The decision to develop on the mainframe, rather than the individual PC/workstation, is more a matter of ignorance than anything else. Today's IS professional is not familiar with the personal computer and therefore knows of only one choice - the mainframe. Some of the applications developed on the familair mainframe would have been more appropriately developed on a PC/workstation. Hopefully, this trade-off will take place less often as the IS professional is educated. Once properly educated, the IS professional will be able to choose the most appropriate computing layer for an application. In order to do this, it will be necessary to understand the capabilities, limitations, and connectivity between the computing layers. As the PC/workstation becomes more prevalent in application design, it will also become important to become educated enough about the personal computer, in order to learn how to exploit it in application design.

In order to succeed in the implementation of cooperative processing applications, IS professionals will have to broaden their skill sets. First, it will be necessary to become proficient in using software and development tools across the computing layers. Because of the new individual PC/workstations and tools available, most of the development work will be done on the PC/workstation. A thorough understanding of the personal computer environment will be necessary in order to use the PC editors, compilers, screen painters, and database management systems. A fundamental change in using a PC/workstation in development will be the emphasis on software. Previously, the aim of software was to ease the workload of the programmer, but now it will be directed more toward user ease. Second, the IS professional will have to develop an understanding of all available hardware and software. This will force project management to become more technical. Just as important, project managers will evolve to become technical, since projects will involve more than people management, but also the coordinating of heterogenous hardware. Third, the IS professional will have to develop sharpened analytical skills. Analysis to determine the computing layer will no longer be directed at the entire application, but at understanding each and every business function. Each business function will be individually assessed within an application for appropriateness within a computing layer. This will require an increased business function knowledge for the IS professional. The ability to adapt to new professional roles will be just as important as technical talent. As IS professionals learn more about the users' business, more of a team effort toward system development can be approached and more joint systems produced. As joint systems are produced, the communication barrier between IS and users will be removed. When this barrier is removed, communication will become easier, user will become more involved, and better systems will be produced. This change in roles should not be viewed as a threat to the IS professional's technical prowess, for few users want to become programmers; they just want to become more efficient in their jobs by leveraging their productivity with the computer. Proceeding in this direction of more interaction with the user community, the IS professional will also have to develop communication and consulting skills because of the increased involvement with non-IS personnel. The IS jargon and isolated attitudes will no longer be tolerated.

Because of the available technology, new types of systems will be able to be developed by the IS professional. In the past, the IS professional was primarily responsible for developing traditional systems that replicated structured business processes. However, today's information systems can be much more diverse. IS will need to continue to develop and maintain traditional systems, but now the IS professional is also being asked to develop systems for which no business model exists. For these systems, the IS professional must be prepared to apply creativity to help the user community better understand their decision making.

The burden of this challenge for IS professionals to significantly adapt to new responsibilities can be lessened. It will become increasingly important for IS personnel to keep pace with new technological advances. More time and effort must be spent on research and development in order to keep up with the proliferation of trade literature.

As technological developments that are reshaping businesses also reshape the IS profession, adaptability and versatility will become the IS professional's greatest assets.

VI. Conclusions

What the PC/workstation did for processing power in the 1980's, cooperative processing will do for application power in the 1990's. Cooperative processing will provide the structure and the context for the next generation of information systems. This new era of computing will be characterized by increased individual empowerment and cooperative synergy in applications development, information analysis, and knowledge sharing.

The anticipation of the integration of PC/workstations within the corporate computing environment has become a realization at this point in time. As the PC/workstation continues to become an integral part of the business environment a much more aggressive schedule for the integration of PC/workstations and PC/workstation connectivity must be implemented. The price to pay for waiting will only get more expensive. Organizations that desire to be in a position to leverage cooperative processing before their competitors, will have to begin understanding cooperative processing now. Cooperative processing is the only logical step in the continuation of extending and enhancing corporate computing. This fast-paced evolution of computing architecture is a significant step towards meeting corporate goals. Through this evolution, cooperative processing will be the catalyst that will ultimately deliver the information systems that businesses need.

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Vita

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